Series 1935, No. 23 Issued April 1942

# Soil Survey

# The Pixley Area California

By
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and
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United States Department of Agriculture

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In cooperation with the
University of California Agricultural Experiment Station

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By R. EARL STORIE, in Charge, and BRUCE C. OWEN, University of California, and M. H. LAYTON, A. C. ANDERSON, W. J. LEIGHTY, and C. C. NIKIFOROFF, Soil Survey Division,[1] Bureau of Chemistry and Soils, United States Department of Agriculture

Area inspected by MACY H. LAPHAM, Inspector, District 5

United States Department of Agriculture in cooperation with the University of California Agricultural Experiment Station

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[1] The Soil Survey Division was transferred to the Bureau of Plant Industry July 1, 1939.

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## AREA SURVEYED

### LOCATION AND EXTENT

The Pixley area is in the southwestern part of Tulare County, Calif., in the San Joaquin Valley. Geographically this area is about 120 miles southeast of the center of the State (fig. 1). San Francisco

FIGURE 1.—Sketch map showing location of the Pixley area, Calif.

is about 225 miles to the northwest; Los Angeles, 145 miles to the south; and Fresno, 75 miles to the northwest. Tulare County has an area of 4,856 square miles, the eastern one-half or more of which is occupied by the foothills and mountains of the Sierra Nevada. The Pixley area comprises approximately the southern half of the western or valley part of the county, together with a narrow belt of foothills along its eastern margin. The northern part of the valley is covered by the previous soil survey of the Visalia area (*9*),[2] which

[2] Italic numbers in parentheses refer to Literature Cited, p. 113.

joins the Pixley area along the line between Townships 20 and 21 South. Waukena lies on the northern boundary and Strathmore a short distance north of it. The area is bounded on the south by Kern County and on the west by Kings County. It extends about 36 miles from east to west and 24 miles from north to south, comprising 25 townships, with a total area of 897 square miles, or 574,080 acres.

The northern part of this area[3] is included in the earlier soil reconnaissance of the Middle San Joaquin Valley (*4*) and the southern part in the soil reconnaissance of the Upper San Joaquin Valley (*7*). The northeastern part is covered by the very early soil survey of the Portersville area (*10*). It is joined on the west by the Hanford area (*6*), which has since been included in a soil survey of Kings County, not yet published.

## PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The landscape and relief of the Pixley area are representative of the San Joaquin Valley and the lower Sierra Nevada foothills on the east. The elevation of the included part of the belt of foothills ranges from about 300 to 1,000 feet above sea level. About 50 to 60 square miles of the area southeast of Terra Bella and Ducor has an undulating relief, and the rest is composed of valley lands having a smooth, gently sloping, alluvial-fan surface.

In the foothill and mountainous areas the soils vary widely in relief, ranging from the steep, stony, rugged, nonagricultural rough stony land to the rolling or hilly soils on the lower foothills included in the Vista, Las Posas, Lassen, and Diablo series. The higher mountains are composed of granitic rocks, with isolated bodies of basic igneous rocks along the western edge. The granites produce light-textured soils (sandy loams), and finer textured rocks produce heavy-textured soils (clay loams and clays).

The Tule River heads high up in the Sierra Nevada and enters the area near Springville, and the South Fork enters near Success. A number of irrigation ditches divert the waters of the Tule River so that very little water passes Porterville except during the winter and spring freshets. In seasons of extreme floods, waters of the Tule River reach Tulare Lake. A number of the old river channels west of Porterville convey irrigation water during the early part of the summer. A large part of the water sinks into the sandy soils of the river delta and flood plain and is later pumped to the surface for irrigation.

Deer Creek enters the area from the lower foothills east of Terra Bella, but surface waters do not flow much farther west than Terra Bella. The White River is a similar type of stream south of Ducor. Both of these streams contribute a certain amount of underground water that is pumped to the surface for irrigation.

These streams have built up alluvial fans, which are occupied mainly by the sandy loam or fine sandy loam soils of the Tujunga, Hanford, Cajon, Greenfield, Hesperia, and Foster series. Lower,

[3] In the Pixley area, because of much greater detail in mapping, data accumulated through years of field study, and development in the science of soil classification since the date of the earlier surveys, which were mainly of broader reconnaissance character many changes from the earlier surveys have been made in soil names, resulting in apparent conflicts in soil classification. The more important of these are noted in the text.

more poorly drained areas are occupied in part by heavier textured Chino soils. All these soils have a smooth surface sloping gently toward the west.

West of these alluvial fans, lower, flatter, or shallow basinlike areas are occupied by soils containing "alkali."[4] All occupy smooth areas where water stands following rains. Soils of the Pond, Lewis, and Fresno series occupy these basinlike areas. They have a microrelief of small knolls and depressions. The mounds generally are sandier textured, contain less alkali, and support more vegetation than the depressions. Both surface drainage and subdrainage are slow in these soils.

In the southwestern part of the area the land is extremely flat and slopes only very slightly toward the west. In former times this section was covered by Tulare Lake. The soil materials are lacustrine in origin, having been laid down in very quiet waters. Sandy ridges extend along the edges of former beach lines. Surface run-off is extremely slow in this district.

The older alluvial terraces and fans, lying at a higher elevation than the surrounding recent alluvial soils, are occupied by red or brown soils locally known as red lands, hog-wallow land, or red hardpan land. Viewed from a distance, the relief appears fairly smooth, but closer observation brings out the hog-wallow microrelief of low mounds and shallow depressions. The mounds range from 5 to 30 feet in diameter and from 2 to 4 feet in height. These terrace lands are drained by channels, but water generally stands in the depressions for a considerable period following heavy rains, as outlets are lacking and the hardpan prevents the percolation of water. These hardpan areas are occupied by soils developed on old alluvial deposits that were laid down at times of heavy run-off from the Sierra Nevada during or following the Pleistocene period. They occur along the eastern side of the San Joaquin Valley. The soils include members of the San Joaquin and Madera series, with minor inclusions of members of the Exeter and Redding series.

In the southeastern part of the area is a body of elevated terraces that are somewhat broken in places by steep slopes. The soils on these terraces are classed in the Ducor series.

### VEGETATION

The native vegetation of the Pixley area is chiefly a dry grassland type, which grows rapidly after the winter rains but remains dry and dormant during the long dry summer. In the foothills the native cover is primarily grasses, such as bromegrass, wild oats, and alfileria, with some brush, scattered oaks, and a few buckeyes. This type of vegetation is characteristic of the Vista soils; the Las Posas soils support fewer oaks; and the Lassen soils, which are derived from fine-textured basic igneous rocks, support no trees at all, but a growth of bur-clover springs up after the winter rains. The hardpan soils of the older fans and terraces have a cover mainly of alfileria, chick-

[4] The term "alkali" is used in this report in its local popular agricultural sense and includes both saline salts of neutral chemical reaction, such as the chloride and the sulfate of sodium, as well as the true alkali carbonates of more toxic character. Both saline ("white alkali") and true alkali ("black alkali") salts are present in many places throughout this area.

weed, and bur-clover; and a few live oak trees grow near drainageways. Where ground water is fairly close to the surface, the soils of the alluvial fans support a growth of oaks, willow, and cottonwood along with the native grasses, but most of the trees have been cut to make way for crops, and the lowering of the ground water by pumping has caused the death of many oak trees in certain districts. Water-loving grasses were prevalent on the delta of the Tule River when the water table was higher, and saltgrass grows in spots that contain some alkali. Sycamore, cottonwood, and willow trees grow along the channels of most of the larger streams. The soils of the flatter and basinlike areas that contain saline salts normally have a cover of salt-tolerant vegetation, such as saltgrass, inkweed, or various kinds of saltbushes. Following the winter rains, chickweed, bur-clover, and a number of low flowering plants abound on the mounds and spots containing little or no alkali. Soils that contain a very high percentage of salts are generally barren.

### SETTLEMENT AND POPULATION

Created in 1852, Tulare County originally extended from Mariposa County on the north to Los Angeles County on the south, and from the summit of the mountains of the Coast Ranges on the west into the Sierra Nevada on the east. In 1856 Fresno County was created from territory taken from Tulare, Mariposa, and Merced Counties. Kern County, cut from the southern part of Tulare, was organized as Buena Vista County in 1855 but was not officially designated Kern until 1866. Minor changes in the Fresno, Tulare, Kings, and Kern County lines were made between 1874 and 1893. In 1893 Kings County was created from the western part of Tulare County.

The first white people settled on the Kaweah River in 1850, about 15 miles north of the northern boundary of this area. This settlement was destroyed by the Indians. Visalia became the county seat of Tulare County in 1853, and practically all of the farming centered in that vicinity. Hunters, traders, and prospectors passed through this territory, but very little attempt was made to settle it until 1864, when the first permanent settlement within the confines of this survey was made at Porterville. At this time there was some farming along the Tule River bottoms. Porterville, with a population of 5,303 in 1930, is the only town of importance within the area surveyed. Smaller towns are Springville, Terra Bella, Ducor, Earlimart, Pixley, Tipton, and Alpaugh. Corcoran, situated a short distance west of the county line in Kings County, had a population of 1,768 in 1930, and Delano, situated over the line in Kern County, had a population of 2,632. Both these towns are used as shopping centers for farmers in the adjacent parts of Tulare County. Towns on the main line of the Southern Pacific Company were founded following its completion in 1872. The Porterville branch of that railroad, along which Ducor, Terra Bella, and Richgrove were founded, was constructed in 1888.

### TRANSPORTATION AND MARKETS

The Pixley area is well supplied with transportation facilities. The San Joaquin Valley line of the Southern Pacific Company passes through the center, and another branch serves Porterville, Terra

Bella, and Richgrove. The main line of the Atchison, Topeka & Santa Fe Railway goes through the southwestern corner of the area, and a branch line follows the edge of the foothills through Porterville.

United States Highway No. 99 parallels the main line of the Southern Pacific through Tipton, Pixley, and Earlimart; the Orange Belt Highway passes through Richgrove, Ducor, Terra Bella, and Porterville; and a paved highway extends eastward from Porterville into the mountains. Paved or oiled roads serve all sections.

Electric power is available in all parts of the area. Schools, churches, and many other social institutions are available. Motorbus transportation is provided for students.

Most of the agricultural produce is marketed outside the limits of this area. Dried and canned fruits, raisins, wines, and citrus fruits are shipped long distances and are widely distributed throughout the world. Table grapes and fresh fruits are marketed throughout the State and other parts of the country.

Dairy products, hay, meats, and truck crops are used locally or marketed in Fresno, Los Angeles, or San Francisco. Cream produced in the Pixley and Tipton districts is manufactured into dairy products at a local plant or shipped fresh to Los Angeles. A large quantity of cotton is shipped from the central and western parts of the area, and cotton gins are located at a number of places in the districts producing cotton. Many cooperative marketing associations handle the agricultural products, especially citrus fruits and poultry products.

## CLIMATE

The climate of the Pixley area is distinctly semiarid. The year has two general seasons—the winter, during which most of the rainfall occurs, and the summer, which is hot and dry. The spring and fall seasons may be considered mainly transitional with fairly warm days and mild nights. The rainless summer with low humidity is ideal for the drying of raisins and other fruits, as well as for the handling of fruits and crops. The mild winters are advantageous for growing truck crops and citrus fruits. Owing to the rainless hot summers, crops cannot be grown successfully in summer without irrigation. Grains are grown without irrigation in winter, when most of the rain falls.

These general climatic conditions with low rainfall have produced a marked effect on the soils, especially regarding their general light color, low content of organic matter, and unleached character.

The annual rainfall in the valley is low, ranging from about 6.90 inches in the southwestern part of the area to about 10 inches along the foothills in the vicinity of Porterville. East of Porterville in the foothills it increases rapidly with increase in elevation. East of Springville, at an elevation of 4,050 feet above sea level, a mean annual rainfall of 32.58 inches is reported. Approximately one-third of the total rainfall comes in the period between April and November, inclusive, and two-thirds in the months of December, January, February, and March. During June, July, and August practically no rain falls. Except for grains and winter and spring grasses, the annual rainfall is not utilized to a great extent for crop production on the valley soils. Irrigation must be practiced during the sum-

mer in order to maintain sufficient moisture in the soil for crop growth. Table 1 gives the mean monthly and annual precipitation as reported by the United States Weather Bureau stations at Angiola and Porterville; at Visalia, Lindsay, Lemoncove, Three Rivers, and Giant Forest and near Springville (outside the area but within Tulare County); and at Hanford in Kings County.

TABLE 1.—*Mean monthly and annual precipitation at several Weather Bureau stations in Tulare and Kings Counties, Calif.*

| Station | Elevation | Length of record | Mean precipitation | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
| | *Ft.* | *Yrs.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* |
| Angiola | 208 | 39 | 1.36 | 1.21 | 1.23 | 0.56 | 0.38 | 0.05 | 0.00 | 0.01 | 0.27 | 0.28 | 0.59 | 0.96 | 6.90 |
| Hanford | 249 | 39 | 1.69 | 1.36 | 1.59 | .60 | .40 | .11 | .00 | .01 | .36 | .28 | .75 | 1.06 | 8.21 |
| Visalia | 334 | 51 | 1.85 | 1.59 | 1.60 | .82 | .49 | .06 | [1] | .01 | .24 | .34 | .79 | 1.27 | 9.06 |
| Lindsay | 384 | 25 | 2.12 | 1.82 | 1.88 | .95 | .62 | .11 | .00 | [1] | .19 | 37 | .89 | 1.39 | 10.33 |
| Porterville | 464 | 50 | 1.93 | 1.70 | 1.77 | 1.01 | .67 | .09 | .01 | .01 | .21 | .42 | .80 | 1.43 | 10.11 |
| Lemoncove | 600 | 39 | 2.48 | 2.73 | 2.53 | 1.35 | .84 | .14 | .00 | .01 | .32 | .54 | 1.31 | 1.81 | 14.06 |
| Three Rivers | 840 | 29 | 3.64 | 3.57 | 3.11 | 1.94 | 1.21 | .20 | .04 | .04 | .48 | 2.75 | 1.70 | 2.47 | 21.15 |
| Springville (near) | 4,050 | 32 | 6.69 | 5.54 | 5.16 | 3.18 | 1.92 | .45 | .05 | .23 | .60 | 1.30 | 3.10 | 4.36 | 32.58 |
| Giant Forest | 6,360 | 17 | 5.67 | 6.80 | 4.31 | 5.14 | 1.90 | 1.06 | .08 | .09 | .35 | 1.44 | 4.17 | 6.18 | 37.19 |

[1] Trace.

Table 2 gives the mean monthly and annual temperatures for the same Weather Bureau stations. Angiola has a mean annual temperature of 61.4° F. and Porterville a mean annual temperature of 63.9°.

TABLE 2.—*Mean monthly and annual temperatures at several Weather Bureau stations in Tulare and Kings Counties, Calif.*

| Station | Elevation | Length of record | Mean temperature | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
| | *Ft.* | *Yrs.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* | °*F.* |
| Angiola | 208 | 39 | 44.3 | 49.8 | 54.2 | 60.1 | 66.6 | 73.3 | 80.7 | 78.7 | 71.9 | 62.1 | 51.4 | 44.0 | 61.4 |
| Hanford | 249 | 39 | 45.3 | 50.7 | 54.8 | 60.8 | 67.2 | 75.4 | 80.7 | 78.7 | 72.3 | 63.0 | 53.0 | 45.3 | 62.3 |
| Visalia | 334 | 50 | 45.7 | 51.3 | 54.5 | 59.8 | 66.6 | 73.9 | 80.5 | 78.8 | 72.3 | 63.8 | 53.9 | 46.3 | 62.3 |
| Lindsay | 384 | 25 | 45.5 | 51.2 | 55.6 | 61.0 | 67.0 | 74.6 | 80.8 | 79.1 | 72.3 | 63.2 | 52.9 | 46.0 | 62.4 |
| Porterville | 464 | 50 | 47.3 | 51.6 | 56.0 | 61.7 | 68.7 | 76.7 | 83.0 | 81.2 | 74.2 | 64.7 | 54.7 | 47.2 | 63.9 |
| Lemoncove | 600 | 44 | 47.0 | 52.1 | 56.2 | 61.5 | 67.8 | 75.8 | 81.9 | 80.0 | 73.6 | 65.3 | 54.7 | 46.9 | 63.6 |
| Three Rivers | 840 | 29 | 45.1 | 50.0 | 54.2 | 59.1 | 65.3 | 72.8 | 79.4 | 77.7 | 71.2 | 62.5 | 53.0 | 46.1 | 61.4 |
| Springville (near) | 4,050 | 32 | 38.8 | 40.9 | 43.8 | 48.2 | 54.6 | 62.7 | 70.5 | 69.3 | 62.5 | 53.8 | 46.8 | 39.7 | 52.6 |
| Giant Forest | 6,360 | 17 | 33.4 | 25.4 | 38.5 | 41.7 | 48.4 | 56.9 | 65.6 | 63.6 | 58.5 | 50.5 | 42.2 | 35.5 | 47.5 |

The winters in general are fairly mild with prevailingly sunny weather, and the summers are hot with maximum temperatures between 100° and 114° F. The daily range between the maximum and minimum temperatures during a single day, especially in the early summer, may be as much as 45°. In general the valley areas close to the foothills are the warmest; Porterville reports a monthly mean temperature 2.5° higher than that at Angiola, which is situated on the floor of the valley.

Frost-free locations are very important in areas where citrus fruits are grown. Most of the citrus plantings are in the so-called thermal

belt along the foothills, where the winter temperatures are higher and conditions of air drainage are favorable. Persons contemplating setting out citrus fruits should make a careful study of the local frost and air-drainage conditions. Orchard heating is not so prevalent as in some other districts of the State, owing to the favorable conditions; but most of the citrus orchards are prepared for heating if a heavy frost should threaten.

The summers are nearly cloudless; in fact, with the exception of a short period during the winter, the percentage of sunshine during the year is very high. Fogs may form in the winter, especially in the early morning. They are low and confined mainly to the lower lands west of the citrus belt. Humidity is very low during the summer but is higher during the winter. The Weather Bureau reports 225 clear days, 68 partly cloudy days, and 72 cloudy days at Porterville in 1938. Visalia, located on an alluvial fan at a lower elevation, had 227 clear days, 37 partly cloudy days, and 101 cloudy days during the same period.

The prevailing winds over most of the area are from the northwest. They are gentle and never attain high velocities. During the winter the winds often come from the south.

Additional data regarding precipitation and frosts are given in tables 3 and 4.

TABLE 3.—*Annual precipitation at several Weather Bureau stations in Tulare and Kings Counties, Calif., in stated years*

| Station | Elevation | Annual precipitation for— | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1925 | 1926 | 1927 | 1928 | 1929 | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 |
| | *Ft.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* |
| Angiola | 208 | 5.89 | 8.24 | 9.19 | 6.52 | 3.42 | 6.61 | 10.73 | 4.61 | 5.63 | 8.27 | 9.37 | 11.95 | 7.49 | 12.60 |
| Hanford | 249 | 6.27 | 10.21 | 10.25 | 5.94 | 4.32 | 6.28 | 9.40 | 5.80 | 5.92 | 7.16 | 10.21 | 11.59 | 9.34 | 13.29 |
| Visalia | 334 | 7.86 | 9.59 | 10.91 | 6.36 | 4.54 | 7.61 | 10.23 | 7.57 | 8.01 | 10.16 | 12.12 | 15.14 | 11.97 | 15.36 |
| Lindsay | 384 | 8.08 | 10.05 | 10.62 | 8.06 | 5.14 | 8.13 | 13.70 | 9.20 | 10.46 | 9.20 | 10.76 | 17.35 | 14.70 | 16.91 |
| Porterville | 464 | 8.88 | 10.65 | 11.65 | 8.49 | 5.27 | 6.94 | 12.22 | 8.03 | 9.80 | 8.21 | 10.21 | 15.67 | 13.76 | 17.15 |
| Lemoncove | 600 | 11.75 | 13.02 | 14.04 | 9.10 | 7.76 | 11.18 | 17.06 | 10.10 | 12.17 | 11.51 | 17.31 | 22.07 | 17.61 | 19.36 |
| Three Rivers | 840 | 17.61 | 18.81 | 19.02 | 14.26 | 9.91 | 16.58 | 23.36 | 14.31 | 18.73 | 13.46 | 21.48 | 30.80 | 27.36 | 27.66 |
| Springville (near) | 4,050 | 20.23 | 35.27 | 37.81 | 25.04 | 20.33 | 32.37 | 36.26 | 25.43 | 34.81 | 22.73 | 38.09 | 50.55 | 53.35 | 48.25 |
| Giant Forest | 6,360 | 36.51 | 45.67 | 43.54 | 25.66 | 25.06 | 33.60 | 46.17 | 33.04 | 40.96 | 23.22 | 39.86 | 63.23 | 57.23 | 54.97 |

TABLE 4.—*Frost data for several Weather Bureau stations in Tulare and Kings Counties, Calif.*

| Station | Elevation | Length of record | Average date of last killing frost in spring | Average date of first killing frost in fall | Average frost-free period | Latest date of killing frost in spring | Earliest date of killing frost in fall |
|---|---|---|---|---|---|---|---|
| | *Feet* | *Years* | | | *Days* | | |
| Angiola | 208 | 38 | Mar. 22 | Nov. 11 | 234 | May 20 | Oct. 12 |
| Hanford | 249 | 37 | Mar. 1 | Nov. 14 | 258 | May 26 | Oct. 11 |
| Visalia | 334 | 34 | Mar. 8 | Nov. 28 | 265 | May 4 | Oct. 26 |
| Lindsay | 384 | 25 | Mar. 18 | Nov. 14 | 241 | Apr. 22 | Oct. 25 |
| Porterville | 464 | 37 | Mar. 10 | Nov. 25 | 260 | Apr. 17 | Oct. 10 |
| Lemoncove | 600 | 36 | Feb. 27 | Nov. 28 | 274 | May 11 | Oct. 4 |
| Three Rivers | 840 | 29 | Mar. 23 | Nov. 15 | 237 | May 10 | Oct. 23 |
| Springville (near) | 4,050 | 20 | May 14 | Oct. 17 | 156 | July 14 | Sept. 13 |
| Giant Forest | 6,360 | 12 | June 4 | Oct. 7 | 125 | June 30 | Sept. 8 |

## AGRICULTURAL HISTORY AND STATISTICS

Following the first permanent settlement in this area in 1864, agricultural development was slow. Gradually the raising of livestock began along the Tule River, and grain farming expanded in the Terra Bella and Ducor districts. With the completion of the Porterville branch of the Southern Pacific Railroad in 1888, the growing of wheat became important. Holdings were necessarily large because crop yields were often low, owing to the scant rainfall. Plantings of citrus fruits increased in number in the nineties, when it was found that the district adjacent to the foothills was relatively frost free.

The growing of alfalfa, deciduous fruits, and grapes on the alluvial flood plains along the Tule River, Deer Creek, and the White River, with the use of pumped water for irrigation, developed on a large scale after 1900. Cotton was not produced in the western part of the county on a large scale until about 1915, but since that time it has become one of the most important cash crops of the area.

The drilling of deep irrigation wells, beginning about 1915, has made possible intensive farming of large tracts of land. As a result of this intensive irrigation development, along with favorable climatic and soil conditions, crops of many kinds are grown, among which the most important fruits are citrus, peaches, apricots, prunes, plums, olives, and figs. Table 5 gives the estimated acreages of fruits in 1930 for Tulare County, issued by the California Crop Reporting Service, and table 6 gives the acreage of irrigated crops as determined in the Pixley area by a survey made in 1929 by the California Department of Public Works, Division of Water Resources.

TABLE 5.—*Estimated acreage of fruits and nuts in Tulare County, Calif., in 1927, 1932, and 1937, as given by the California Crop Reporting Service*

| Crops | 1927 [1] | 1932 [1] | 1937 [2] | Crops | 1927 [1] | 1932 [1] | 1937 [2] |
|---|---|---|---|---|---|---|---|
| | *Acres* | *Acres* | *Acres* | | *Acres* | *Acres* | *Acres* |
| Almonds | 360 | 461 | 303 | Oranges—Continued | | | |
| Apples | 732 | 308 | 334 | Navel | 25,497 | 25,701 | 22,626 |
| Apricots | 2,876 | 1,319 | 932 | Valencia | 11,111 | 11,101 | 10,513 |
| Avocados | 4 | 4 | 4 | Other | 245 | 906 | 754 |
| Cherries | 30 | 5 | 6 | Olives | 6,085 | 6,203 | 5,560 |
| Figs, all | 4,100 | 5,751 | 2,961 | Peaches, all | 7,238 | 8,572 | 8,035 |
| Kadota | 250 | 671 | 520 | Clingstone | 4,238 | 5,660 | 3,821 |
| Other | 3,850 | 5,080 | 2,441 | Freestone | 3,000 | 2,912 | 4,214 |
| Grapes, all | 82,141 | 60,069 | 57,554 | Pears (Bartlett) | 491 | 39 | 21 |
| Raisin | 58,227 | 37,395 | 37,239 | Persimmons | 47 | 120 | 85 |
| Table | 19,358 | 17,496 | 16,745 | Plums | 5,129 | 3,196 | 2,264 |
| Wine | 4,556 | 5,178 | 3,570 | Pomegranates | | | 415 |
| Grapefuit | 852 | 784 | 814 | Prunes | 6,644 | 8,253 | 5,279 |
| Lemons | 1,326 | 1,341 | 1,120 | Quince | | | 17 |
| Limes | | | 9 | Walnuts | 1,080 | 1,975 | 2,165 |
| Nectarines | | | 286 | | | | |
| Oranges, all | 36,853 | 37,708 | 33,893 | Total | [3] 155,988 | [3] 136,108 | [3] 122,057 |

[1] From (unrevised) estimates of California fruit and nut crop acreages for the years 1927 to 1932, issued by the California Department of Agriculture (*2*).

[2] From (revised) estimates of California fruit and nut crop acreages as of 1937, issued by the California Cooperative Crop Reporting Service (*3*).

[3] Includes total acreages only.

TABLE 6.—*Acreage of irrigated crops in the Pixley area, and proportion of total acreage irrigated in Tulare County, Calif., in 1929* [1]

| Crops | Acres | Percent of total acreage of each crop irrigated in county | Crops | Acres | Percent of total acreage of each crop irrigated in county |
|---|---|---|---|---|---|
| Alfalfa | 13,297 | 24.3 | Deciduous fruits | 4,601 | 16.0 |
| Irrigated pasture | 6,128 | 36.6 | Figs | 670 | 15.4 |
| Irrigated grain | 6,822 | 67.6 | Olives | 1,052 | 18.6 |
| Miscellaneous field crops | 4,116 | 33.9 | Walnuts | 807 | 29.0 |
| Cotton | 52,316 | 75.3 | Grapes | 16,768 | 22.6 |
| Citrus fruits | 9,648 | 26.0 | | | |

[1] Field survey made by C. H. Holley for the California Department of Public Works, Division of Water Resources.

The more important field crops include alfalfa, cotton, barley, wheat, and sorghums. Truck crops include peas, tomatoes, asparagus, lettuce, potatoes, squash, watermelons, cantaloups, and Casaba and Persian melons. Walnuts are the only nuts grown. Grapes for table, juice, and raisin purposes are important.

According to the 1935 census, [5] of the 3,107,840 acres in Tulare County, 1,138,465 acres, or 36.6 percent, were in farms. The average size of the farms was 166.3 acres. Of the land in farms, 534,372 acres were classed as cropland and plowable pasture, and 572,873 acres were classed as pasture land. In 1929, 410,683 acres were irrigated, averaging 101.8 acres to the farm. In 1909, 739 irrigation pumping plants were reported in Tulare County. The number increased to 3,758 in 1920 and to 7,964 in 1930.

The proportion of farms operated by tenants in 1935 was 22.1 percent. In 1929, $8,052,787 was spent for farm labor in the county and $1,378,096 was spent for fertilizers.

### CITRUS FRUITS

Tulare County ranks fourth in California in the total acreage of citrus fruits, and approximately 74 percent of the total acreage is north of the area included in this survey, in the Orange Cove, Lemoncove, Exeter, Lindsay, and Strathmore districts (*9*). Of the total of 35,836 acres in citrus fruit trees in the county in 1937, navel oranges occupied 22,626 acres, Valencia oranges 10,513 acres, other oranges 754 acres, lemons 1,120 acres, grapefruit 814 acres, and limes 9 acres.

The citrus district in this area lies along the foothills in the vicinities of Porterville, Success, Terra Bella, Ducor, and Richgrove, at an elevation of about 400 feet. This is known as the thermal belt because of the better air drainage, higher temperatures in winter, and less frost hazard.

Citrus fruits are grown on a wide variety of soils, ranging from coarse sandy loam to heavy clay in texture, and from 1 to 6 feet or more in depth to hardpan or bedrock. In locating citrus plantings, the first thing considered usually is the local climatic conditions, such as frost hazards and air drainage, followed by the soil

[5] Census statistics quoted here are for Tulare County as a whole.

moisture and irrigation conditions. It has been found that the deeper medium-textured soils give the best results as regards tonnage of fruit and long life of trees.

It is the common practice to grow mustard or other natural weeds in the orchards during the winter, although leguminous cover crops are grown in some orchards. The cover crop or natural weed growth is generally plowed under in early spring. Fertilizers are used in the citrus orchards. The agricultural extension service in Tulare County recommends the following fertilization program for citrus orchards: From 5 to 8 tons per acre of manure, depending on the quality of the manure and the amount of cover crop grown, plus 1 pound, more or less, of actual nitrogen for each tree, according to the size of the tree and the previous fertilizer practice. It is suggested that the manure be broadcast in late summer or fall and shortly before the soil is to be worked, and that the chemical fertilizer be broadcast during the fall or early winter so as to allow the rain to carry it down into the ground. One pound of nitrogen is supplied by 5 pounds of ammonium sulfate, or by 6½ pounds of nitrate of lime or nitrate of soda. Phosphoric acid and potash have not given profitable returns where they have been tested by the extension service and by growers. In most orchards heaters are provided to protect the trees against frosts, although many growers do not need to operate them if their orchards are in protected sites where air drainage is good.

Bearing orange orchards yield from 50 to 300 packed boxes to the acre. The average acre yield for navel oranges in Tulare County during the period between 1922 and 1927, according to the California Citrus League, was 138.4 packed boxes. This average yield might have been higher if all the orchards had been furnished with an ample water supply. The prevalence of mottle leaf also has lowered the yields. With control of mottle leaf by the use of zinc and with an ample water supply, no doubt the yield could be increased considerably. In studies carried on by the University of California cooperating with the State Division of Water Resources (*1*) it was found that, with a yield of 138 packed boxes an acre and a price to the grower of $2.19 a packed box, the acre return would pay preharvest costs of $190 an acre, harvest costs at 24 cents a packed box, interest at 6 percent on an average investment of $750 an acre, $34.10 for irrigation water, and additional profits above the labor income to the operator and the interest on the average investment. At present water ranges in cost from $25 to $36 an acre.

#### PEACHES AND APRICOTS

Scattered plantings of peaches are maintained on the light-textured deep alluvial soils of the Foster, Cajon, Hanford, Hesperia, and Greenfield series west of Porterville, near Woodville, Poplar, Sausalito School, and farther south along the Kern County boundary line north of Delano. Figures are not available on the acreage within the limits of this survey. Both clingstone and freestone varieties are grown. The principal clingstone varieties are Orange Cling, Phillips Cling, Palora, and Tuskena (Tuscan), and the chief freestone varieties are Muir, Elberta, and Lovell. With the exception of a few early-ripening varieties of light yield, such as Hale Early, very few peaches are grown on the hardpan soils. In general,

good soils are necessary in order to maintain high yields of peaches at low cost. The Foster, Cajon, Hanford, Hesperia, and Greenfield sandy loams and fine sandy loams are very suitable for the culture of peaches. The average yield of peaches as determined by studies of the agricultural extension service in Tulare County is 7.72 tons an acre. Assuming a selling price of $25 a ton, this gives a gross income of $193 an acre. Efficiency studies carried out in Tulare County show the total cost of production to be $105 an acre with an additional cost of harvesting of $4.50 to $5.50 a ton. With a yield of 7.72 tons an acre, the total cost of production and harvesting is $143.60 an acre, which leaves about $50 an acre for cost of irrigation water and interest. The peach trees are irrigated in basins or by furrows. The irrigation season extends from March to September. Practically no commercial fertilizers are used, but the use of barnyard manure is common. Cover crops are grown in some orchards during the winter. They consist mainly of mustard or weeds, and some annual yellow sweetclover (*Melilotus indica*) is grown as a cover crop and is plowed under in February or March.

The acreage of apricots is not large. This fruit is grown on the same soils and in the same districts as peaches. Tilton and Blenheim are the principal varieties. In general, apricot orchards are managed in much the same way as peach orchards.

### PLUMS AND PRUNES

Most of the plums and prunes in Tulare County are grown not in the Pixley area but in the Visalia area. The crop reporting service reported a total of 5,279 acres of prunes and 2,264 acres of plums in 1937 for the entire county. Nearly all the prunes are of the French variety. Plums for shipping are chiefly of the Santa Rosa, Beauty, Climax, and Tragedy varieties. Plums and prunes grow best on the medium-textured soils of the Hanford, Tujunga, Foster, Cajon, Greenfield, Hesperia, and Chino series, which are free from an excess of soluble salts. The general field practices are very similar to those for the other deciduous fruits. Manures and cover crops are used to some extent.

### FIGS AND OLIVES

The acreage of figs and olives in this area makes up only a small part of the total in the county. Most of the figs and olives are grown farther north in the Lindsay, Exeter, Lemoncove, and Ivanhoe districts. In 1929, 670 acres of figs and 1,052 acres of olives were reported under irrigation in this area. Both figs and olives are planted on a wide variety of soils. Many of the plantings are on the hardpan soils of the San Joaquin, Madera, and Exeter series. Figs of the Kadota variety are grown on a small acreage, and the rest are of the Mission, Adriatic, and Smyrna varieties. No established practice of fertilization is used for figs or olives.

### WALNUTS

The survey of irrigated crops made in 1929 reported 807 acres of walnuts within the area covered by this soil survey, and probably a number of plantings have been made since. Most of the walnuts

are grown near the Tule River on the deep sandy soils of the alluvial flood plains, such as those of the Tujunga, Cajon, and Foster series. The trees do not do well on the hardpan soils of the San Joaquin and Madera series. Franquette is the chief variety of walnuts, and smaller acreages are devoted to the Eureka and Mayette varieties.

#### GRAPES

Among the counties of California, Tulare County ranks second to Fresno County in the total acreage in grapes. In 1929 a total of 16,768 acres of irrigated land was devoted to grapes in this area, or 22.6 percent of the total acreage of grapes in the county. Based on use, the grapes may be classed as raisin, table, and juice. Some varieties, such as the Alexandria (Muscat of Alexandria), however, can be sold under all three classes. The principal raisin grapes include the Alexandria and the Sultanina (Thompson Seedless) varieties; the table varieties are the Emperor, Malaga, Flame Tokay, and Cornichon; and the juice grapes include the Alicante Bouschet, Mission, Zinfandel, Alphonse Lavalle (Ribier), and Carignane. Raisin and juice varieties are grown on the largest acreage. With the resumption of wine making in 1933, a greater expansion in the acreage in vineyards took place, especially of the wine varieties of grapes. Grapes are grown chiefly on the soils of the Hanford, Greenfield, Foster, Cajon, and Hesperia series that occur between the hardpan soils and the basin soils containing an excess of soluble salts.

Raisin grapes are best suited to the sandier soils, such as Tujunga sandy loam, Foster loamy sand, Foster fine sandy loam, Cajon sandy loam, Cajon fine sandy loam, Greenfield sandy loam, Hesperia sandy loam, and Hesperia loam. The long dry summer seems to be ideal for the maturing and drying of raisin grapes. Common yields from full-bearing vineyards of raisin grapes range from 1 to 2 tons of raisins an acre. A yield of 1½ tons an acre is probably a reasonable figure to use for those who wish to calculate on prospective incomes from raisins. As the price of raisins has fluctuated widely (from 1½ to 13 cents a pound) during the last 20 years, it is difficult to set an average price. With a price of 3¼ cents a pound the gross income is about $97.50 an acre. Cost-of-production studies carried on by various agencies show figures that range from $75 to more than $100 an acre. Assuming a preharvest cost of $50 an acre, a harvesting cost of $16 a ton, and 6 percent interest on an investment of $262.50 an acre, gives a total cost of $89.75 on a 1½-ton yield. This leaves a margin of $7.75 an acre to pay for irrigation water.

Table grapes yield from 4 to 6 tons an acre. Most of the table grapes seem to give the best results on the medium-textured soils, such as fine sandy loam or loam. The Flame Tokay grape does better on the medium heavy textured soils. Very little cultivation is practiced except where water is very expensive. Applications of 3 to 6 tons of manure are used by many growers, together with a winter crop of wild mustard or occasionally annual yellow sweetclover. Some growers use about 300 pounds of ammonium sulfate to the acre.

Juice or wine grapes are grown on a wide variety of soils, but in this area the soils are about the same as those used for table or raisin grapes. Most of the grapes are used in the manufacture of

sweet wines, such as muscatel, sherry, angelica, and port. The making of dry wines is relatively unimportant in this area.

### ALFALFA

In 1929, 13,297 acres of alfalfa were reported in the Pixley area. The 1935 census reported 40,322 acres in the county, producing 160,822 tons of hay. The acreage of alfalfa has been reduced during the last 15 years, as many of the growers have changed to cotton. The alfalfa-growing districts are west of Woodville, in the vicinity of Tipton, around Alpaugh, and south of Waukena. Alfalfa is grown in connection with dairying, as feed for the dairy cattle, and very little is shipped.

The chief requirements for alfalfa are a deep soil that absorbs water readily and is easy to irrigate by the flooding system. For this reason, the soils of the Cajon, Foster, Hanford, Greenfield, Hesperia, and Chino series are suited to the culture of alfalfa. The more common irrigation practice is by means of strip border checks at intervals of 14 to 21 days between April 1 and October 1. An annual supply of 2 to 4 acre-feet of water must be available for each acre in alfalfa.

Chilean is the principal variety, and Peruvian is grown to less extent. Alfalfa is usually planted between September 15 and November 15 and is allowed to remain for a number of years or as long as the stand is good. Where not pastured, alfalfa is cut for hay about once each month. Yields range from 4 to 10 tons an acre, with an average of about 5 tons a year from five or six cuttings. Studies by various agencies have given a total cost of $55 to $65 an acre, exclusive of the cost of water. This includes interest at 6 percent on a capital land value of $200 an acre. With alfalfa selling at $14 a ton this would leave from $5 to $15 an acre to pay for water. Some growers of alfalfa have changed to cotton because of the mounting water costs due to the lowering of the underground water table.

### COTTON

About 75 percent of the acreage in cotton in Tulare County is in the Pixley area. In 1929, 52,316 acres were reported in this area, of a total of 69,534 acres in the county. The Federal census reports 64,403 acres grown with a production of 61,260 bales for the county. In 1919 only 297 acres were reported for the entire county.

Yields of cotton range from ¾ to 2½ bales an acre. On good land the better growers expect 1½ bales an acre. Acala is the only variety planted. From 20 to 30 acre-inches of water is used for cotton. The common practice is to give a heavy irrigation before planting and then to give three or four irrigations during the growing season. Usual irrigation costs are from $10 to $12 an acre a year.

The best soils for cotton are deep, are free from excessive quantities of soluble salts, and hold a moderate amount of moisture. As a general rule the soils of this area have a good content of plant nutrients. Ammonium sulfate is used to some extent to supply nitrogen.

Most of the cotton in the Pixley area is grown in the central part, in the vicinities of Woodville, Pixley, Tipton, and Earlimart, and to some extent in the Alpaugh district.

### GRAINS

The wheat-growing district is in the vicinities of Terra Bella, Ducor, and Richgrove, on soils of the San Joaquin, Madera, Exeter, Delano, and Ducor series. The 1930 census reports 68,583 acres of wheat grown in 1929, producing 691,566 bushels, and 17,502 acres of barley, producing 293,004 bushels. In 1934, 20,377 acres of wheat were grown, producing 181,674 bushels, and 8,805 acres of barley, producing 177,209 bushels. These figures are for the entire county, but much of the dry-farmed grain is grown in the southern part of the county. Small areas of grains grown under irrigation are west of Porterville and on the Tulare soils in the Alpaugh district.

Dry-farmed grains are limited by the low rainfall. The common practice is to summer-fallow 1 year out of 3. From 10 to 18 bushels an acre are the common yields under this practice. Under irrigation, yields range from 15 to 40 bushels an acre. Grain grown under irrigation is limited to areas where the water is relatively cheaper, such as that obtained under gravity or by pumps with a low lift.

### MISCELLANEOUS FIELD AND TRUCK CROPS

Egyptian corn, feterita, milo, and kafir are grown under irrigation, as summer crops, west of Porterville on the alluvial soils of the Foster, Cajon, and Chino series. The demand for these grain sorghums as poultry and hog feed is considerable. Yields range from 1,000 to 3,500 pounds an acre. Sorghums are grown to some extent for silage.

Scattered patches of corn are grown for silage in connection with dairying. Most of the corn is grown on the darker colored alluvial soils of the Foster and Chino series. The low humidity and the hot summers are not favorable for growing corn.

The acreage of truck crops varies from season to season. Potatoes are grown in the Delano district on the Hanford, Greenfield, and Hesperia soils. Peas to be shipped fresh, together with tomatoes and squash, are grown along the foothills, where the danger of frost is least. Watermelons, cantaloups, and Casaba and Persian melons are grown on the sandier alluvial soils.

### IRRIGATED PASTURE

In 1929, 6,128 acres of irrigated pasture land was reported in this area. To a considerable extent the grasses include wild grasses, on which water is flooded during the early summer while there is a heavy flow in the rivers. Most of the pasture lands are soils of the Chino, Pond, Lewis, and Fresno series that contain an excess of soluble salts and are not used for cultivated crops.

### LIVESTOCK

Tulare County ranks high as a producer of dairy products. Most of the dairying in this area is within a radius of 15 miles of Tipton. The largest proportion of the dairy products of the county, however, are produced outside of this area in the Tulare district. The dairy districts in general are in the same localities where alfalfa is produced. Alfalfa is used principally for feed for dairy cattle. The quantity of sorghums and corn grown for cattle feed in these districts

is increasing, and the quantity of concentrates fed, including barley, beet pulp, and cottonseed meal, is not large but is increasing. About 90 percent of the cows are of the Holstein-Friesian breed. Some farmers have shifted from dairy farming to cotton growing, owing to the increased cost of pumping irrigation water in some districts.

The raising of beef cattle in the Pixley area is confined to the irrigated pasture lands and to the foothill section. Feeders are imported from outside the area and fattened on the grasses, supplemented by cottonseed meal and grains. Breeding in general is confined to the higher mountain ranches, which lie outside the limits of this area to the east. The chief range feed includes redstem alfileria, wild oats, bromegrass, and bur-clover. The amount of range feed is governed by the annual rainfall. In years of low rainfall the sandier soils provide the best pasture, but in seasons of heavy rainfall the heavier textured soils provide the best. Soils of the Pond, Lewis, and Fresno series, which contain an excess of soluble salts, produce very little pasture in dry years, but in years of high rainfall they provide fair grazing. Hereford is the principal breed of beef cattle.

The number of hogs kept is not large. Hampshire and Duroc-Jersey are the principal breeds, and there are a few Poland China and Chester White.

Poultry raising is centralized in the vicinity of Porterville on Cajon sandy loam, Cajon fine sandy loam, and Foster fine sandy loam. This is mainly an egg-producing district, and White Leghorn is the principal breed of chickens. Poultry raising and egg production could be considerably increased in this area. Sandy soils furnish the more desirable sites for poultry farms.

## SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [6] and its content of lime and salts are determined by simple tests.[7] Drainage, both internal and external, and other external features, such as relief, or lay of the

[6] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity. The term "basic" is used as synonymous with "alkaline" as used by chemists. It denotes not an excess of soluble salts (alkali), but an alkaline reaction. The term "alkaline" is purposely avoided in this publication, because of the popular conception of its meaning. "Basic" is used throughout to express the same idea.

[7] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline (basic) reaction. Lime (calcium carbonate) is detected by hydrochloric acid. "Calcareous" means containing lime in sufficient quantity to be detected by the application of dilute hydrochloric acid. "Non-calcareous" means not containing lime in sufficient quantity to be so detected. A soil may contain an abundance of available calcium and yet not be calcareous in the foregoing sense.

land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or bare rocky mountainsides, that have no true soil, are called (4) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Hanford, Chino, and Foster are names of important soil series in this area.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Chino loam and Chino clay loam are soil types within the Chino series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for certain soil types, some areas are adapted to the use of machinery and the growth of cultivated crops and others are not. Even though no important differences exist in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, important differences are observed in the growth of cultivated crops. The more sloping parts of such soil types are segregated on the map as a sloping or hilly phase. Similarly, some soils having differences in stoniness are mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes. section and town-

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ship lines, and other local cultural and natural features of the landscape.

## SOILS AND CROPS

The soils of the Pixley area have been developed under distinctly semiarid climatic conditions and therefore have characteristics that are different from those of soils developed where the rainfall is higher. With few exceptions, the soils are low in organic matter and distinctly basic in reaction. A large proportion of them effervesce when tested with dilute hydrochloric acid, indicating a high content of lime. Many of the soils occupying the lower, flatter areas on the floor of the valley west of Tipton, Pixley, and Delano have an accumulation of soluble salts of sodium and calcium, such as the chlorides, sulfates, and carbonates. As a general rule, the soils of the area are well supplied with most of the mineral plant nutrients. Nitrogen is generally low, owing to the low organic-matter content; but this can be built up by the incorporation of manure or the plowing under of cover crops.

The soils of the Pixley area fall into four major soil groups based on development of soil profile, in which a definite relationship exists between the soil profile and the physiographic landscape, as shown in figure 2 and table 7.

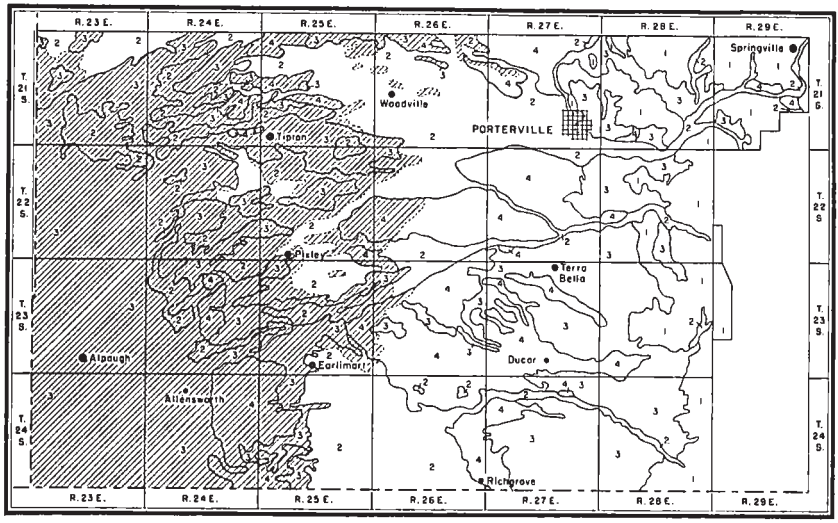


FIGURE 2.—Major soil groups in the Pixley area, Calif.: 1, Soils with bedrock substrata; 2, soils with permeable subsoils; 3, soils with slightly to moderately dense subsoils; 4, soils with hardpan substrata. (Shaded areas indicate soils containing alkali.)

TABLE 7.—*Grouping of the soil series of the Pixley area, Calif.*

| Soil series | Mineralogical composition | Color of surface soils | Topography |
|---|---|---|---|
| (1) Soils with bedrock substrata: | | | |
| Vista | Granitic | Brown, reddish-brown, or grayish-brown variations. | Foothills. |
| Lassen [1] | Basic igneous | | |
| Las Posas | do | | |
| Diablo [1] | Mixed or undetermined | Dark brownish gray or dark gray. | |
| Linne [1] | do | | |
| (2) Soils with permeable subsoils: | | | |
| Hanford | Granitic | Brown, reddish-brown, or grayish-brown variations. | Smooth, gently sloping recent and young alluvial fans and flood plains. |
| Greenfield | do | | |
| Hesperia [1] | do | | |
| Honcut | Basic igneous | | |
| Tujunga | Granitic | Light gray or light brownish gray. | |
| Cajon [2] | do | | |
| Foster [2] | do | Dark brownish gray or dark gray. | |
| Chino [2] | do | | |
| (3) Soils with slightly to moderately dense subsoils: | | | |
| Porterville [1] | Basic igneous | Brown, reddish-brown or grayish-brown variations. | Sloping to flat older alluvial fans and valley plains. |
| Delano [1] | Mixed or undetermined | | |
| Chualar | do | | |
| Ducor [1] | do | | |
| Tulare [1 3] | do | | |
| Hacienda [2 3] | do | Light gray or light brownish gray. | |
| Pond [2 3] | Granitic | | |
| Waukena [2 3] | do | | |
| Traver [1 3] | do | Dark brownish gray or dark gray. | |
| Hovey [1] | Basic igneous | | |
| (4) Soils with hardpan substrata | | | |
| Redding | Mixed or undetermined | Brown, reddish-brown or grayish-brown variations. | Sloping to flat older alluvial fans and valley plains, with a hog wallow microrelief. |
| Exeter | Granitic | | |
| San Joaquin | do | | |
| Madera [1] | do | | |
| Fresno [2 3] | do | Light gray or light brownish gray. | |
| Lewis [2 3] | do | | |

[1] Calcareous in subsoils.
[2] Calcareous throughout.
[3] Soils typically containing alkali.

(1) Soils with bedrock substrata occupy rolling, hilly, or mountainous relief in the foothills and lower mountains along the eastern margin of the area. They rest on the parent bedrock at a depth ranging from a few inches to 4 feet. These soils are classed in the Vista, Las Posas, Lassen, Linne, and Diablo series. Associated steep rough areas containing very little soil material and a large quantity of stone are designated as rough stony land (Vista soil material) or merely rough stony land. The Vista soils are brown or, in places, reddish brown and are developed on granitic bedrock. The light brownish-red or light reddish-brown soils developed on fine-textured igneous parent rock material are classed in the Las Posas series, and the dark-brown heavy-textured soils developed on fine-textured igneous rocks and having a calcareous subsoil are classed in the Lassen series. The Diablo soils, occurring in the extreme southeastern part of the area, have gray or dark-gray noncalcareous surface soils and subsoils that are developed on consolidated marine shale, clays, and conglomerates. The Linne soils are of similar origin but are dull grayish brown.

(2) The alluvial deposits of the valleys have been washed from the mountains and foothills and accumulated on alluvial fans, in stream bottoms, or on flat areas of the valley plain. Characteristics of the soils developed on these materials depend on the kind of parent materials,

the drainage, and the length of time the soils have been subjected to environmental conditions giving rise to differences or stages in profile development. Large areas of the more recent of these deposits occur on the flood plain of the Tule River west of Porterville, as outwash from Deer Creek and the White River, and as small alluvial fans along the edge of the foothills. These deposits have given rise to soils unmodified by environmental conditions, or that represent very youthful stages in profile development, and are characterized by permeable subsoils. They occupy gently sloping recent and young alluvial fans and flood plains.

Soils of the Hanford, Honcut, Tujunga, Cajon, and Foster series are of recent deposition and undeveloped profile. They differ in parent material, color, and lime content. The Greenfield, Hesperia, and Chino soils have slightly modified or more mature profiles with slightly more compact or slightly heavier textured subsoils. These soils are indicated under the second group. In general most of these soils are adapted to a wide range of crops, especially cotton, alfalfa, deciduous fruits, vines, and general farm crops.

(3) Soils of the alluvial fans or flood plains that have undergone further development, with the formation of fairly compact to moderately dense heavier textured subsoils, are represented by the Porterville, Hovey, Delano, Ducor, Chualar, Pond, Traver, Tulare, Waukena, and Hacienda series.

The Porterville soils have chocolate-brown heavy-textured surface soils and subsoils having a high accumulation of nodular lime. The Hovey soils have a profile similar to the Porterville soils but are dark gray. The soils of both series are derived from parent material made up of outwash from fine-textured basic igneous rocks. Soils in both series are extremely heavy in texture.

The Delano soils have brown surface soils and subsoils that are slightly heavier textured and more compact than the surface soils and contain considerable lime. In this area the Delano soils are somewhat mixed in origin, but they contain considerable mica and other minerals from granitic sources.

Soils of the Ducor series have dark grayish-brown surface soils, with grayish-brown or brownish-red compact highly calcareous subsoils. They rest on an unconsolidated substratum of secondary granitic materials containing a variety of minerals. The Ducor soils occupy gently to moderately rolling old alluvial fan surfaces east of Terra Bella, Ducor, and Richgrove. The Chualar soils are dark grayish brown and occur in association with the Ducor soils in narrow valleys. The subsoils are somewhat heavier textured and more compact, but, like the Ducor soils, they are noncalcareous and contain considerable mica and minerals from quartz-bearing rocks.

The Pond soils occupy the flat alluvial plains in association with the Fresno soils in the western part of the area. They are light gray or light brownish gray and have moderately compact subsoils stratified with heavy-textured materials. The surface soils and subsoils are highly calcareous and micaceous. They generally contain alkali and differ from the Fresno soils in the absence of the cemented calcareous hardpan layer.

The Tulare soils have gray calcareous surface soils. The subsoils are of silty clay texture, fairly compact, and highly calcareous. Stratified layers of sandier material occur in many places in the lower subsoil layers. The soil material contains shells or fragments of shells of fresh-water mollusks. The soils of this series occupy smooth flat lake beds consisting of sediments of mixed origin. As the subsoils have a moderate to high content of alkali these soils are shown on the soil sketch map (fig. 2) with the alkali soils.

The Hacienda and the Waukena soils are related to and associated with the Tulare and the Pond soils, from which they are distinguished by dense subsoils of columnar and solonetzlike structure.

(4) Occupying higher terraces and old valley plains above the flood plains of the stream bottoms are remnants of brown soils with a hardpan. These terraces slope gently toward the west but generally have a hog-wallow surface configuration characterized by small mounds and depressions. Included in this group are the soils of the Exeter, San Joaquin, Madera, and Redding series. All are characterized by a hardpan layer at a depth ranging from 1 to 4 feet below the surface.

The Exeter soils have brown noncalcareous surface soils and subsoils resting on a "red iron" hardpan similar to that of the San Joaquin soils. The surface soils of the San Joaquin soils are reddish brown and have a redder heavy-textured subsoil overlying the hardpan. The members of the Madera series have brown surface soils with calcareous subsoils and a hardpan that is browner, softer, and more calcareous than that of the San Joaquin or Exeter soils. The Exeter, San Joaquin, and Madera soils are derived from coarse-textured igneous parent material that was laid down originally as alluvial fan and flood plain deposits but has been materially weathered and altered since that time.

The soils of the Redding series have light reddish-brown noncalcareous surface soils and brownish-red very compact heavy-textured noncalcareous subsoils resting on a hardpan with embedded gravel and cobbles of mixed origin. These soils occupy high terraces along the Tule River.

In the western part of the area and extending between the alluvial fans in flat or shallow basinlike areas, soils of two series—the Fresno and Lewis—occur. They have calcareous hardpans and normally a high content of alkali. The vegetation consists of saltgrass, inkweed, and other salt-tolerant plants.

The Fresno soils are light gray, are high in lime, and have silty cemented calcareous hardpan lenses or thin layers occurring at a depth ranging from 1½ to 3½ feet. The Lewis soils are very similar to the Fresno soils but have heavy-textured darker colored upper subsoil layers of columnar structure. In most places the hardpan is a little more massive in the Lewis soils and the materials in the mineralogical composition are more varied than in the Fresno sails. Both the Fresno and Lewis soils have little value for agriculture because of their high content of soluble salts.

Twenty-nine soil series represented by 67 types and phases, together with 3 miscellaneous land types are recognized and mapped in the Pixley area. In the following pages the different soils are described

in detail, and their agricultural relationships are discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are shown in table 8.

TABLE 8.—*Acreage and proportionate extent of the soils mapped in the Pixley area, Calif.*

| Soil type | Acres | Percent | Soil type | Acres | Percent |
|---|---|---|---|---|---|
| Vista sandy loam | 5,888 | 1.0 | Chualar sandy clay loam | 2,368 | 0.4 |
| Las Posas clay loam | 448 | .1 | Chualar sandy clay loam, shallow phase (over San Joaquin soil material) | 896 | .2 |
| Las Posas stony clay loam | 3,264 | .6 | Chualar clay | 1,344 | .2 |
| Lassen stony adobe clay | 16,448 | 2.9 | Delano clay loam | 8,064 | 1.4 |
| Lassen clay | 2,048 | .4 | Pond loam | 40,128 | 7.0 |
| Diablo adobe clay | 1,920 | .3 | Pond clay loam | 1,472 | .3 |
| Linne clay | 1,280 | .2 | Traver fine sandy loam | 40,000 | 7.0 |
| Hanford sandy loam | 17,920 | 3.1 | Waukena fine sandy loam | 832 | .1 |
| Hanford loamy fine sand | 768 | .1 | Tulare fine sand | 6,592 | 1.1 |
| Hanford loamy fine sand, shallow phase (over Madera soil material) | 2,880 | .5 | Tulare very fine sandy loam | 18,112 | 3.2 |
| Tujunga sandy loam | 512 | .1 | Tulare loam | 9,728 | 1.7 |
| Tujunga sand | 5,440 | .9 | Tulare clay loam | 23,680 | 4.1 |
| Tujunga stony sand | 1,664 | .3 | Tulare clay | 18,368 | 3.2 |
| Honcut loam | 320 | .1 | Hacienda fine sandy loam | 1,472 | .3 |
| Foster loamy sand | 832 | .1 | Porterville adobe clay | 13,440 | 2.3 |
| Foster fine sandy loam | 5,440 | .9 | Porterville stony adobe clay | 3,328 | .6 |
| Foster fine sandy loam, shallow phase (over Madera soil material) | 5,760 | 1.0 | Hovey adobe clay | 1,088 | .2 |
| Foster loam | 1,152 | .2 | Ducor clay loam | 7,040 | 1.2 |
| Cajon sandy loam | 4,992 | .9 | Ducor clay loam, rolling phase | 5,056 | .9 |
| Cajon sandy loam, shallow phase (over Madera soil material) | 512 | .1 | Ducor adobe clay | 27,648 | 4.8 |
| Cajon sandy loam, shallow phase (over Chino soil material) | 2,880 | .5 | Ducor adobe clay, rolling phase | 4,541 | .8 |
| Cajon fine sandy loam | 13,888 | 2.4 | Ducor clay | 5,952 | 1.0 |
| Cajon fine sandy loam, shallow phase (over Madera soil material) | 4,928 | .9 | Exeter sandy loam | 7,616 | 1.3 |
| Cajon fine sandy loam, shallow phase (over Pond soil material) | 3,520 | .6 | Exeter loam | 20,288 | 3.5 |
| Greenfield sandy loam | 7,168 | 1.2 | Exeter clay loam | 128 | (1) |
| Hesperia sandy loam | 23,936 | 4.2 | San Joaquin loam | 25,216 | 4.4 |
| Hesperia loam | 11,648 | 2.0 | San Joaquin clay loam | 4,672 | .8 |
| Chino fine sandy loam | 7,104 | 1.2 | Redding gravelly loam | 1,280 | .2 |
| Chino sandy loam | 640 | .1 | Madera loam | 12,928 | 2.3 |
| Chino loam | 23,232 | 4.1 | Madera clay loam | 448 | .1 |
| Chino loam, shallow phase (over Madera soil material) | 1,088 | .2 | Lewis fine sandy loam | 3,840 | .7 |
| Chino clay loam | 15,616 | 2.7 | Fresno fine sandy loam | 4,416 | .8 |
| Chino clay loam, shallow phase (over Fresno soil material) | 4,480 | .8 | Fresno clay loam | 20,544 | 3.6 |
| Chualar clay loam | 3,072 | .5 | Rough stony land | 14,848 | 2.6 |
| | | | Rough stony land (Vista soil material) | 12,928 | 2.3 |
| | | | Riverwash | 1,088 | .2 |
| | | | Total | 574,080 | |

[1] Less than 0.1 percent.

### VISTA SERIES

The members of the Vista series have light-brown or reddish-brown surface soils. When wet they are generally a little darker or more red. The soils contain a large proportion of small sharp quartz fragments and pieces of unweathered granite. The reaction is basic in most places (7.0–7.5).[8] They are friable and break down to soft clods or single grains. The depth of the surface soils ranges from a few inches to about 2 feet, depending to a considerable extent on the amount of erosion or fill on slopes. The subsoils overlying the parent bedrock are light reddish brown or brownish red. They are generally somewhat heavier in texture than the surface soils and slightly or moderately compact. When wet they are soft, but they dry fairly hard and break into angular blocks. Considerable coarse angular granitic rock

[8] The reactions or pH values reported in descriptions of soil series and types were determined by simple field methods, generally by Soiltex or LaMotte equipment.

fragments are present, which give the subsoil a coarse feel, masking the finer particles. This layer has a pH value ranging from 7.0 to 8.0. In many places a thin layer of brownish-red gritty clay loam or gritty clay overlies the bedrock, which occurs at a depth ranging from 6 inches to 3 feet and averaging about 2 feet.

The Vista soils are of residual origin, having formed in place directly through disintegration and decomposition of the underlying granitic bedrock. They occupy hilly or rolling relief characterized by a few rock outcrops (pl. 1, *A*). Where the surface cover of grass or brush is removed, erosion is fairly active; but as most of the steeper areas of Vista soils in this area are used for pasture, erosion is not so active as in other parts of the State where the soils are cultivated. Surface run-off is fairly rapid, subdrainage is generally good, and alkali salts are not present. Originally, these soils had a cover of oak trees, brush, and grass; but the brush and trees have been removed to a considerable extent by man and fires. A fairly good growth of grasses and herbaceous plants springs up after the winter rains.

Only Vista sandy loam was recognized in this area. It occupies a narrow rim along the eastern edge. The Vista soils were included in the earlier reconnaissance surveys with the Holland soils, from which they are now known to differ in having a basic reaction. The Holland soils typically occur under an annual rainfall ranging from 20 to 50 inches, whereas the Vista soils occur under lower rainfall and represent the arid and semiarid counterpart of the Holland soils.

**Vista sandy loam.**—Vista sandy loam has a rich reddish-brown or light-brown sandy loam surface soil containing numerous sharp angular quartz particles that give it a gritty feel. The soil is very friable and does not become sticky when wet, although sufficient colloidal clay is present to cause it to bind together when dry. It absorbs water readily but has only moderate water-holding capacity because of its coarse texture. The subsoil is of about the same color and texture as the surface soil, although in places it is slightly heavier textured and redder. This soil contains no distinct claypan or hardpan. The underlying parent granitic bedrock occurs at a depth ranging from a few inches to about 4 feet, but the average depth is probably about 2½ feet. The organic-matter content is relatively low. Although the reaction is moderately basic, the soil does not effervesce with dilute acid. Drainage is fairly rapid, and water running off the surface causes erosion in places where the soil is exposed by tillage. Irrigation is difficult on some of the steeper slopes, and contour irrigation and cultivation are advisable in such places.

Areas of Vista sandy loam occur in the foothills below the mountainous section in the eastern part of the area. This soil is not very extensive. The larger areas are northwest of Success, southwest of Springville, near Fountain Springs, and east and northeast of Quincy School.

Only a small proportion of the land is used for cultivated crops, as the limited supply of irrigation water is used on more level land. Where the soil is deep enough and the slope is not excessive, irrigated crops do well. The organic-matter content should be built up when the land is farmed, and care should be used in tillage and irrigation of the steeper slopes to prevent accelerated erosion.

West of Springville along the Tule River, where water is available for irrigation, thrifty citrus plantings are maintained. Truck crops also are grown under irrigation. Early tomatoes of excellent quality are produced on this soil with irrigation. Commercial fertilizers high in nitrogen and heavy applications of barnyard manure are used with citrus and most truck crops.

Some areas of Vista loam contain stony spots that are too small to delineate on the map, yet they lower the agricultural value of the soil. Grain does not return very high yields, owing to the low rainfall of the area. With normal winter rainfall native grasses and associated plants provide good pasturage, although the grasses dry fairly early in the summer.

### LAS POSAS SERIES

The surface soils of members of the Las Posas series are pronounced reddish brown or light brownish red, and they appear redder when wet. The surface layer has a coarse granular structure and contains a fair to low amount of organic matter. The reaction is basic, with a pH value of 7.2 to 8.0, but the soils do not effervesce when tested with dilute hydrochloric acid. Flat angular rock fragments generally are present throughout the soil mass. The surface soil in most places ranges from 6 to 18 inches in thickness and grades into a light brownish-red slightly more compact subsoil of about the same or slightly heavier texture. This layer is noncalcareous but is basic in reaction. Bedrock lies from 6 to 30 inches below the surface. It is schistose in character, and the topmost 4- to 12-inch layer generally is broken into fragments.

The Las Posas soils are developed in place over the underlying parent bedrock, which is composed of fine-grained igneous and metamorphosed rocks, such as amphibolite schists. These soils occupy rolling or fairly steep slopes, and stones and rock outcrops are common. Erosion is active on the steeper slopes where the vegetation is removed. Both surface drainage and subdrainage are excellent. The native vegetation consists principally of grasses and associated herbaceous plants, and a few oak trees grow on the north slopes.

The Las Posas soils differ from the Vista soils in mineralogical composition; they are developed from igneous and metamorphosed rocks that are finer grained and less high in mica and quartz than the parent rocks of the Vista soils. This kind of parent material gives rise to the alluvial soils of the Honcut series when washed down and deposited in the valley on alluvial fans or slopes. The Las Posas soils were included with the Holland or the Olympic soils in the earlier reconnaissance surveys (*4*, *7*) but have since been recognized as representing a distinct series of soils. They are related to the Lassen soils as mapped in this survey but differ chiefly in color and lime content. Las Posas clay loam and Las Posas stony clay loam are mapped in the Pixley area.

**Las Posas clay loam.**—Las Posas clay loam has a light brownish-red or pronounced reddish-brown clay loam surface soil. The subsoil is similar to the surface soil, except that it contains less organic matter and generally contains some flat angular fragments of stone. The parent bedrock occurs from 2 to 3 feet below the surface and

consists of fine-textured basic igneous rocks of schistose character. The surface soil and the subsoil are permeable to roots and moisture, and they have a fairly high content of water. They have a tendency to be a little sticky when wet. The organic-matter content of the soil is low, but generally the soil is productive where not too shallow. Both the surface soil and the subsoil are basic in reaction but do not effervesce when tested with dilute hydrochloric acid. Erosion is fairly active on some of the steeper slopes.

Las Posas clay loam has a very small total area. It occurs in small bodies near Success and South Tule School. These bodies are cleared and are now being used to grow citrus fruits under irrigation.

**Las Posas stony clay loam.**—The surface soil of Las Posas stony clay loam consists of pronounced reddish-brown or light brownish-red stony clay loam or, in places, stony loam. The subsoil is generally brownish-red stony clay loam, resting on the parent bedrock at a depth ranging from 1 to 2½ feet, but the average depth is about 21 inches. The bedrock is composed of amphibolites and similar types of fine-grained rocks (pl. 1, *B*). The soil is low in organic content, and it is of basic reaction.

The water-holding capacity of this soil is relatively high, but rainfall has a tendency to run off the surface, because of the excessive slope, rather than to penetrate the soil. Erosion is fairly active on the steeper slopes, especially where the vegetative cover is removed. The relief is very steep in many places.

The native vegetation consists of grasses and herbaceous plants and a few oak trees. Many of the trees have been removed, but the other plants have not been plowed under, as the soil is used for grazing. The value of this soil for agricultural purposes is governed by the slope, the thickness of soil, and the quantity of stones. In general, the value is low for crops, and the land is used solely for pasture. In small favorable locations the stones might be removed and the soil used for growing citrus fruits.

This soil is located in the foothills east and northeast of Success and in the southeastern part of the area southeast of Quincy School. The total area is not large. East of Success one small area has been cleared of stones and is planted to citrus fruits. Probably 85 percent of the land is too steep for any tilled crops.

### LASSEN SERIES

The Lassen soils of the Pixley area were included with the Olympic soils of the reconnaissance surveys. They are now recognized as conforming better to the Lassen series, which was established at a later date.

The surface soils of members of the Lassen series are brown, dark brown, or chocolate brown when dry and become somewhat darker when wet. The surface soils are fairly friable and develop a granular or small-clod structure, the fragments being more or less angular or slightly rounded. A fair quantity of organic matter, consisting of grass roots and remains of annual plants, is present. The surface soils seem to contain much colloidal clay, as they are very smooth and somewhat sticky when wet. Throughout the surface layer are many small stones and fragments of basic rocks, mainly serpentine

and gabbro. The depth of this layer ranges from a few inches to 2½ feet or more in spots and averages between 12 and 15 inches. The material in this horizon is neutral or basic in reaction but does not effervesce with a weak solution of hydrochloric acid.

The subsoils are chocolate brown. They are only slightly more compact than the surface soils and show evidence of the work of earthworms. Lime is present in both disseminated and mycelial form. Where lime is present in large enough quantities, it tends to make the subsoils friable, although they contain a good deal of colloidal clay. Penetration of roots and moisture is restricted somewhat by the heavy clay texture. The thickness of this layer, which rests on the parent bedrock, ranges from 6 to 12 inches.

These soils are residual, having developed in place from basic igneous and metamorphosed rocks, mainly serpentines and gabbros. They occupy steep to rolling hills and are characterized by many rock outcrops. In general, the slope is too steep and the rock outcrops are too numerous to allow use of these soils for agriculture. A fairly large area is mapped, especially of the stony type. The main bodies of these soils occur in the foothills of the Sierra Nevada east of Porterville and Terra Bella, where they are associated with the Las Posas, Diablo, and Vista soils.

The greatest value of these soils is for pasture. During years of normal and more than normal rainfall there is a very good growth of alfileria and grasses, mainly wild oats, needlegrass, foxtail, and squirreltail. These plants represent the native vegetation, as the Lassen soils are treeless. Lassen clay is used for agriculture to some extent, and in productivity it rates about 2½ times better than Lassen stony adobe clay.

**Lassen stony adobe clay.**—The surface soil of Lassen stony adobe clay, to an average depth of 15 inches, consists of dark-brown or chocolate-brown noncalcareous clay. The adobe structure breaks down to a granular or small-clod structure under favorable field conditions. When wet the soil is plastic and sticky. It has a high content of colloidal clay and a moderate content of organic matter. Many small fragments of basic rocks occur throughout the soil mass. At a depth ranging from 12 to 20 inches is a chocolate-brown calcareous clay subsoil containing many small basic igneous rock fragments. The lime is both disseminated and in accumulations that take on a mycelial form. The subsoil is of about the same friability as the surface soil and has a granular or small-clod structure when dry. When wet it becomes somewhat darker, very sticky, and very plastic. At a depth ranging from 20 to 30 inches the subsoil rests on basic igneous bedrock composed mainly of gabbro and serpentine.

Lassen stony adobe clay is a residual soil, having developed in place from the basic igneous bedrock (pl. 2, *A*). It occupies steep sloping hills on which numerous rock outcrops occur. Although the slopes are rather steep, little or no erosion takes place, owing to the grass cover and the structural condition of the soil, which affords fairly good penetration of water. This soil has a native cover of alfileria, needlegrass, wild oats, foxtail, and squirreltail. It supports no trees. The relief is too steep and rocky for cultivation, and the land is used only for pasture. It is very improbable that this soil will ever be used for agriculture, as the cost of removing the stones would be pro-

hibitive and the steep slopes would make cultivation very difficult. It occupies an extensive area extending along the foothills of the Sierra Nevada along the eastern boundary of the area. The larger bodies are east of Ducor, Terra Bella, and Porterville.

Lassen stony adobe clay is closely associated with the Porterville soils, which are developed on the lower slopes of the hills on which the Lassen soils occur. It is also associated with the Ducor, Las Posas, and Diablo soils.

**Lassen clay.**—Lassen clay is identical with Lassen stony adobe clay in color, profile development, mode of formation, and parent material, but the adobe structure is not so well developed in the clay and the surface is fairly free of rocks, making agriculture possible on the less steeply sloping areas. The land is used mainly for pasture, with a few small areas devoted to dry-farmed grain, mainly wheat. This soil is much less extensive than Lassen stony adobe clay. Small bodies are southeast of Quincy School, 6 miles directly east of Terra Bella, 5 miles south of Success, and in the vicinity of Success.

### DIABLO SERIES

Where typically developed, the surface soils of members of the Diablo series are basic in reaction and dark dull gray or black to an average depth of about 12 inches. Typically most of them are heavy textured and break into large adobelike blocks or chunks. The upper part of the subsoil is dark grayish brown or dark gray, is calcareous, and effervesces with a weak solution of acid. The lower part of the subsoil, below a depth of 24 inches, is light gray and in most places contains gray lime incrustations. The substratum or parent bedrock lies at an average depth of about 40 inches. It consists largely of marine shale, with some layers of conglomerate and some inclusions of basic rock near the margins of the soil bodies.

The Diablo soils are developed in place from the underlying rocks, which are considerably mixed in character. Eroded mesalike areas are included, which may represent very old outwash fans. The material at the foot of the slopes is partly talus and colluvial material. These soils are developed on hilly or rolling relief and would be subject to erosion if cultivated. The soil profile is well developed in the more level areas, but it is more feebly expressed in areas having considerable slope. These soils are covered with grass and herbaceous plants, together with some sagebrush and other semiarid shrubs. They are used entirely for grazing. They are well drained and free from alkali.

In this area the Diablo soils are associated with the Lassen, Linne, and Ducor soils. They differ from the Lassen in having somewhat darker surface soils, in having deeper highly calcareous subsoils, and in being derived mainly from shale and mixed rock material rather than basic rocks; they differ from the Ducor soils in having darker surface soils and parent bedrock substrata, and from the Linne soils in having a darker color and lower lime content. In this area the Diablo series is represented by one type, Diablo adobe clay.

**Diablo adobe clay.**—The surface soil of Diablo adobe clay is dark-gray, dark brownish-gray, or nearly black clay about 12 inches thick. The lighter gray color is most pronounced when the material is dry.

The material is plastic when wet; on drying it shrinks, cracks with wide deep fissures, and develops a characteristic adobe structure, with angular blocks ranging from 2 to 6 inches in diameter. Under favorable conditions these blocks break down into angular coarsely granular or small-clod aggregates.

The upper part of the subsoil, between depths of 12 and 24 inches, is grayish-brown or tan-brown heavy plastic clay containing many grass roots. This layer contains some gray specks and incrustations of lime, and the content of lime increases with depth. The lower part of the subsoil varies considerably, owing to variation in depth to the underlying parent material. Where the parent bedrock occurs at a slight depth, the lower part of the subsoil is pale-gray or bluish-gray heavy clay containing specks of yellow and rust brown that give it a faint yellow shade. This material passes into raw shale at a depth ranging from 36 to 48 or more inches. Where the depth to the parent material is greater, the lower part of the subsoil, at a depth ranging from 24 to 48 inches, is grayish-brown heavy plastic clay containing splotches and incrustations of soft segregated lime. Very few roots are in the lower part of the subsoil.

The substratum, or parent material, is largely grayish-green marine shale, with included layers of softly cemented conglomerate. In some spots in the north-central part of the one large body south of Quincy School, this soil is underlain by basic or granitic rocks. The areas of deeper bedrock occur where this soil borders the Ducor soils on the west, which are derived from transported material. A few narrow belts or streaks of gravelly material derived from conglomerate bedrock are included with this soil in mapping.

Diablo adobe clay occurs in the foothill belt in the eastern part of the area. The rolling to hilly relief would subject the cultivated soil to erosion, but none of the land is cultivated at present (pl. 2, *B*). It supports a good growth of native grass and flowering plants, with very little brush and other vegetation, and is considered a good soil for pasture. It would not be a desirable soil for farming, owing to its steep relief, heavy texture, and rather slight depth. It is free from alkali. Water is not available for irrigating this soil.

### LINNE SERIES

The soils of the Linne series are closely related to the Diablo soils, from which they differ in the lighter brownish gray or gray color and calcareous character of the surface soils and in the lighter color and higher lime content of the subsoils. The soils are granular and friable. Practically none of them develops the blocky or coarse cloddy adobe structure of the Diablo soils. Compared with those soils, the Linne soils are developed under lower rainfall, on slopes more strongly exposed to the sun and rapid evaporation, or on more highly calcareous parent materials. The series is represented in this area by a single type—Linne clay—which is relatively inextensive.

**Linne clay.**—The surface soil of Linne clay is medium dark gray or dark brownish-gray granular friable clay, which breaks into pea-sized and small nut-sized angular fragments. At an average depth of about 12 inches the material grades into dark grayish-brown friable clay, which breaks into irregular aggregates and is splotched

with white lime incrustations. The lime increases with depth. At a depth ranging from about 18 to about 40 inches the subsoil is a light tan-brown clay splotched and streaked with conspicuous white segregated lime. The material is compact when dry but is easy to penetrate with a crowbar, and it breaks into small blocky fragments. This material passes abruptly into white or light-gray soft strata of very high lime content, which break into irregular horizontal layers. This material is easily shattered with a crowbar but is penetrated by roots with difficulty. This horizon is from 2 to 3 feet thick and may be underlain by clay, which, in turn, is underlain by parent bedrock. Both the surface soil and the subsoil are highly calcareous.

For a soil in a semiarid region, the surface soil contains considerable organic material, which is closely associated with the high lime content. This soil seems to have a high water-holding capacity, as it remains moist for some time after the beginning of the dry season. Water penetrates the granular surface soil and into the cracks of the subsoil.

Linne clay occurs principally in sloping mesalike areas. The surface relief is undulating or gently rolling, with steep slopes along marginal breaks. Only a few bodies of this soil, aggregating a small total area, are in the eastern part of the area. None of the land is cultivated. Irrigation is impracticable, owing to the elevation and lack of water. As it supports a good growth of native grass, it is considered a good soil for grazing.

#### HANFORD SERIES

The soils of the Hanford series are characterized by light-brown, brown, or grayish-brown surface soils that are friable, generally single grain in structure, micaceous, noncalcareous, although neutral or slightly basic in reaction, and moderately low in organic-matter content. The subsoils, beginning at a depth ranging from 10 to 18 inches, are slightly lighter in color but otherwise are very similar to the surface soils. No compaction or evidence of the development of an illuviated horizon is noted. The substratum consists of similar material extending to considerable depth. Stratified layers of various textures, ranging from loam to loamy sand, may be present in the subsoil and substratum.

The Hanford soils consist of recent alluvial materials derived largely from granitic sources, deposited by streams flowing out of the Sierra Nevada and its foothills. In this area the parent materials have been derived largely through erosion of the Vista soils. They occur on alluvial bottoms in areas generally slightly elevated above the present flood plains and on broad, smooth, gently sloping alluvial fans. No erosion is evident, and in this area drainage is excellent and the soils are free from alkali. The native vegetation consists of grasses, herbaceous plants, and oaks.

The Hanford soils are associated with soils of the Tujunga, Cajon, Foster, Greenfield, and Hesperia series. They differ from the Tujunga in that they are browner and contain more organic matter; from the Cajon, Foster, and Hesperia soils in being noncalcareous throughout; and from the Greenfield soils in having less compact

subsoils and undeveloped profiles. The Hanford is an old established series of soils occurring extensively along the eastern side of the San Joaquin Valley. In this area, Hanford sandy loam and Hanford loamy fine sand, with a shallow phase, are mapped. They are good to excellent soils, well adapted to a wide variety of crops.

**Hanford sandy loam.**—The surface soil of Hanford sandy loam is light-brown or brown sandy loam having a rich-brown appearance when wet. The subsoil, below a depth of 10 to 16 inches, consists of light-brown sandy loam that shows no compaction or accumulation of clay or colloids. The substratum, to a depth of several feet, resembles the subsoil, but the subsoil and substratum may include stratified layers ranging from loam to loamy sand in texture. The entire soil mass contains considerable mica and more or less sharp or angular large quartz grains. This soil consists of relatively recent deposits laid down by running water and derived largely from granitic sources.

The entire soil material is very friable, somewhat loose, and largely single grain in structure. In places the surface soil may pack slightly and clod somewhat when dry, but not enough to prevent easy tillage operations. The soil is deep, is permeable to roots, and absorbs water readily, holding from 10 to 15 percent of water.

Although this soil is noncalcareous throughout, it is neutral to slightly basic in reaction, ranging in pH value from 7.0 to 8.0. Typically, the soil contains no injurious accumulations of alkali, but one small area about 5 miles northeast of Porterville contains a slight amount of alkali in the lower part of the subsoil. This area represents an overwash of Hanford material over a soil very similar to the Fresno soils. The organic-matter content and the nitrogen content are moderately low.

This soil occupies alluvial stream bottoms in areas that are slightly above the present flood plains, and it also occurs extensively on broad alluvial fans. The land is smooth and has a gentle slope favorable to cultivation, so that little or no leveling is necessary to prepare the land for irrigation. No erosion is evident, and none of the soil is subject to overflow except a few small areas adjacent to streams in times of exceptionally high floods. Both surface drainage and subdrainage are excellent. The ground-water level ranges from 20 to 100 feet below the surface.

A fairly large total area of Hanford sandy loam is mapped. It occurs extensively south, southeast, and east of Earlimart on the alluvial fans of the White River and Rag Gulch, where it is typically developed. Smaller scattered areas are south of Allensworth, adjacent to the White River north of Vestal, and in the vicinities of Tipton, Woodville, Poplar, Porterville, Success, and Springville. This soil is associated with Tujunga sand, Cajon fine sandy loam, Greenfield sandy loam, Hesperia sandy loam, and Hesperia loam.

On the alluvial fans the native vegetation consists largely of grasses, with a few scattered oaks. Along the alluvial bottoms, where moisture is usually more plentiful, the growth includes some willows, cottonwoods, vines, and shrubs. More than 95 percent of this soil is cleared and in cultivation, and probably more than 60 percent of the total area is in grape vineyards. Where supplied with suffi-

cient water, the soil is well adapted to the growing of grapes, which return good to excellent yields ranging from 5 to 8 tons an acre. The soil is well adapted to a wide variety of crops, such as cotton, wheat, barley, apricots, and peaches, and good to excellent yields are obtained in most years. Irrigation is necessary for all crops except grain, which is generally dry-farmed. Water is obtained largely by pumping from wells, although a few areas on the alluvial bottoms near the streams are supplied with water by gravity. The addition of organic matter in the form of barnyard manure or by plowing under green cover crops is very beneficial.

**Hanford loamy fine sand.**—The surface soil of Hanford loamy fine sand consists of light grayish-brown or light-brown loamy fine sand extending to a depth of 15 to 18 inches. The subsoil is very similar to the surface soil, except that it is slightly light yellow, and is without compaction or accumulation of clay or colloids. The substratum is similar to the subsoil, and both the subsoil and the substratum may contain stratified layers of various textures. The entire soil mass contains much mica. This soil consists of relatively recent deposits laid down by running water and derived largely from granitic sources.

The entire soil material is extremely friable and is largely single grain in structure. It is easily worked and is very permeable to roots and water to considerable depths. Water is absorbed readily, and a large quantity of available water is held. Although the soil is noncalcareous throughout, it is neutral to slightly basic in reaction, ranging in pH value from 7.0 to 8.0. It contains no alkali. The organic-matter and nitrogen contents are moderately low.

Hanford loamy fine sand occurs on broad alluvial fans, as outwash material deposited by the various old or recent channels of Deer Creek and the White River. It has a smooth surface with a gentle slope toward the streams, and little or no leveling is necessary to prepare the land for irrigation. No erosion is evident, and none of the land is subject to overflow. Both surface drainage and subdrainage are excellent. The ground-water level ranges from 30 to 50 feet below the surface.

Hanford loamy fine sand is an inextensive soil. The principal areas are about 2 miles south of Poplar, from ½ to 3 miles southeast of Sausalito School, and about 3 miles southeast of Earlimart. This soil is associated with Hanford loamy fine sand, shallow phase (over Madera soil material), Hanford sandy loam, Tujunga sand, and Hesperia loam. Where associated with Hanford loamy fine sand, shallow phase (over Madera soil material), the soil rests in places on a Madera subsoil or hardpan at a depth of 6 feet or more.

The native vegetation consisted largely of grasses and flowering annuals, with a few scattered oaks. All the land is cultivated, the principal crops being cotton, grapes, apricots, peaches, and grain. This is an excellent soil for a wide variety of crops, and usually very good yields are obtained. All this soil is irrigated by water pumped from wells. Its productivity is improved by the application of barnyard manure and the growth of green-manure crops.

**Hanford loamy fine sand, shallow phase (over Madera soil material).**—The surface soil of this phase consists of light grayish-

brown or light-brown friable micaceous noncalcareous loamy fine sand. Below a depth of 15 to 18 inches this becomes slightly lighter in color but otherwise is similar to the surface soil. At a depth ranging from 2 to 4½ feet this material rests abruptly on light-brown or reddish-brown somewhat compact and slightly dense clay loam which contains lime in the form of seams or soft nodules. In some places this layer is absent or very thin. It is underlain, at a depth ranging from 2½ to 5½ feet, by a brownish-red or reddish-brown hardpan, which becomes less red and more brown with depth. The hardpan contains various quantities of lime in the form of seams and soft nodules. It ranges from 1 to 2 feet in thickness and overlies light yellowish-brown or light yellowish-gray micaceous loose sandy material of undetermined depth.

Soil of this phase represents an overwash of Hanford loamy fine sand over an older soil similar to the Madera soils. The surface soil of the buried Madera soil in most places is absent, and in some places the subsoil also is absent. In such places the Hanford soil rests directly on the hardpan. This soil occurs under similar conditions and relief as does typical Hanford loamy fine sand. Subdrainage is restricted because of the presence of the impervious hardpan layer. This layer also prohibits root development into or below it. The soil material generally is deep enough over the hardpan so that development of most roots is not greatly restricted. None of this soil shows any evidence of accumulations of alkali.

This shallow soil covers a small total area. The largest bodies are from 1 to 2 miles south of Poplar and in the vicinity of Sausalito School. This soil is associated with typical Hanford loamy fine sand, Hanford sandy loam, Tujunga sand, Madera loam, and the Cajon and Foster fine sandy loams, shallow phases (over Madera soil material). Small areas that are slightly calcareous in the lower part of the surface layer are included with this soil in mapping. The color of the surface soil varies somewhat, a few areas being slightly darker than typical.

More than 80 percent of this soil is cultivated, and the rest is in grass that is used for pasture. Cotton, grain, grapes, apricots, peaches, and alfalfa are the most important crops, and good yields are generally obtained. The presence of the hardpan makes this soil less valuable than typical Hanford loamy fine sand, and its value varies directly with the depth to the hardpan. Where the soil is shallow over the hardpan, development of roots is restricted in places and there is danger of applying too much water when irrigating. All the cultivated crops except certain grains are irrigated.

### TUJUNGA SERIES

The typical surface soils of members of the Tujunga series, to a depth of 8 to 15 inches, range in color from light brownish gray to light gray, but they appear more brown when wet. As mapped, they include browner variations transitional to the Hanford soils. They are very friable, generally coarse textured, porous, and single grain in structure. Mica, angular quartz grains, and other rock fragments derived from granitic sources are abundant. The reaction is neutral

or basic, with a pH value ranging from 7 to 8, but no effervescence results when the soil is treated with dilute hydrochloric acid. The organic-matter and nitrogen contents are very low. The subsoils and substratum to considerable depth are very similar to the surface soil, indicating that little or no development of a profile has taken place. Generally, both the subsoil and the substratum contain stratified layers of various textures. In most places gravelly or coarse sandy layers occur in the lower part of the subsoils or substratum. There are no injurious accumulations of alkali.

The Tujunga soils consist of recent alluvial sediments deposited by streams. They have been derived largely through erosion of the Vista soils developed from granitic rocks. Deposition of soil material is still active in some areas. These soils occupy recent alluvial flood plains and alluvial fans, and many of the areas are subject to overflow during periods of heavy rainfall. The surface is flat or gently sloping, in places interrupted by low ridges or old channels that were formed during torrential floods. Drainage is excellent to excessive, except in areas near present streams during the rainy season flood periods. The native vegetation consists of willows, cottonwoods, oaks, shrubs, vines, herbaceous plants, and grasses.

The Tujunga soils are associated with and related to the Cajon, Hanford, and Foster soils. They are distinguished from the Cajon soils by being noncalcareous, from the Foster soils by being noncalcareous and lighter in color, and from the Hanford soils by being lighter in color and of lower organic-matter content. They are much less productive and important than the Hanford soils. Three soil types are mapped in this area—Tujunga sand, Tujunga stony sand, and Tujunga sandy loam.

**Tujunga sandy loam.**—The surface soil of Tujunga sandy loam, to a depth ranging from 8 to 15 inches, is light brownish-gray or light-gray sandy loam that appears more brown when wet. This soil includes some browner areas transitional to the Hanford soils. The subsoil is generally similar to the surface soil, although it may be slightly lighter in color and coarser in texture. It shows no compaction or evidence of any development of a soil profile. Both the subsoil and the substratum commonly contain stratified layers of alluvial materials ranging from fine sandy loam to coarse sand, but in most places consisting mainly of the coarser textures. The entire soil mass is micaceous and contains more or less sharp angular quartz grains. This soil consists of very recent deposits laid down by running water and derived largely from granitic sources.

The soil is extremely friable, somewhat loose and porous, and single grain in structure, making it very easy to work. It is easily permeable to roots and absorbs water readily, although the water-holding capacity is low and frequent irrigations are usually necessary. The entire soil material is noncalcareous, although it is neutral to slightly basic in reaction. It is free from alkali. The organic-matter and nitrogen contents are very low.

This soil occupies recent alluvial flood plains. In most places the land is smooth and flat to gently sloping, but in some places low ridges or shallow channels have been formed by swiftly flowing floodwaters. Where adjacent to present rivers and streams, this soil is

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subject to floods during periods of heavy rainfall, and during torrential floods new channels and ridges are formed. Drainage is excellent or excessive, except near drainageways during periods of heavy rainfall and flood.

Tujunga sandy loam is a very inextensive soil. It occurs in small bodies adjacent to the old and present channels of Deer Creek north and northeast of Terra Bella and near the White River north of Vestal. It is associated with Tujunga sand, riverwash, Hanford sandy loam, and Cajon sandy loam.

The native vegetation consists of willows, oaks, shrubs, vines, grasses, and associated plants. Approximately 80 percent of this soil is cleared. About half of the total area is in crops, and the rest is used for grazing. Wheat, the principal crop, is grown without irrigation. This soil is not very productive, as its productivity is limited by its low water-holding capacity, low organic-matter content, and danger of overflow.

**Tujunga sand.**—The surface soil of Tujunga sand, to a depth of 8 to 10 inches, is light brownish-gray loamy sand that appears somewhat more brown when wet. As mapped this soil includes some areas of a browner soil approaching the Hanford soils. Tujunga sand is loose, porous, and single grain in structure, although it is sufficiently coherent to form soft clods on drying. The subsoil and the substratum, to a depth of several feet, are very similar to the surface soil, but in most places they are slightly lighter in color. These two layers generally are stratified, the materials being of various textures, in many places consisting of coarse sand or fine gravel. The entire soil mass contains much mica, more or less angular quartz grains, and other rock particles derived largely from granitic sources. The soil consists of sediments transported and deposited by rivers and creeks flowing out of the Sierra Nevada and foothills.

Roots penetrate readily to a great depth in this loose, very friable, and very easily worked soil. Water is absorbed readily, but the water-holding capacity is very low, making the soil droughty and leachy and necessitating frequent irrigations. The entire soil material is noncalcareous, although it is neutral or slightly basic in reaction. No injurious accumulations of alkali occur. The organic-matter and nitrogen contents are very low. Applying barnyard manure and plowing under green-manure crops are very beneficial in increasing the water-holding capacity and the organic-matter content.

This soil occupies recent alluvial flood plains and alluvial fans, which are flat or gently sloping, except that low ridges or shallow channels have been formed in places by swiftly flowing floodwaters. Adjacent to streams, the soil is subject to floods during periods of heavy rainfall, and new channels and ridges are formed occasionally. Surface run-off is slight, as the rainfall is readily absorbed; and subdrainage is excellent or excessive.

This soil occurs on the alluvial flood plains and alluvial fans of the Tule River, the White River, and Deer Creek—principally as long narrow strips adjacent to the stream channel or in old abandoned channels. It is closely associated with riverwash and the Hanford and Cajon soils.

*A*, Vista sandy loam in foreground. Note rock outcrop on left and higher hills in distance occupied by rough stony land. *B*, Profile of Las Posas stony clay loam, showing shallow soil material developed on metamorphosed basic igneous rocks.

*A*, Lassen stony adobe clay, showing the shallowness of the soil and the lime-incrusted rock fragments; *B*, rolling land in the eastern part of the area, occupied by Diablo adobe clay.

The native vegetation consists mainly of willows, cottonwoods, oaks, shrubs, vines, and grasses. Probably 85 percent of this soil is used for pasture, a large part of it being uncleared, and the rest is used for grape vineyards, general farm crops, and chicken ranches. Yields generally are rather low, unless the land is fertilized and properly irrigated.

**Tujunga stony sand.**—Tujunga stony sand is similar to Tujunga sand, except that it contains numerous cobbles and stones, ranging in diameter from 3 to 25 inches, and, in places, some gravel. The stones and gravel have been transported and deposited by torrential floods from the mountains to the east.

This soil covers a small total area on the alluvial flood plains of both forks of the Tule River above Success and near South Tule School. It is associated with Tujunga sand.

Most of the land is used for pasture, and a large part of it still supports a cover of trees, shrubs, and vines. Pasture on this soil has a low carrying capacity because the soil is so stony, droughty, and leachy. The land has little agricultural value for crops because the presence of the stones prohibits tillage operations. It is subjected to damaging floods, and the water-holding capacity and the organic-matter content are very low.

### HONCUT SERIES

The Honcut soils, as they occur in this area, have brown surface soils, with a reddish-brown tint in the areas of heavier textured soils. They contain small angular fragments of schistose and other fine-textured basic igneous rocks throughout the soil mass. The surface soils grade into light-brown subsoils that do not show consistent compaction or accumulation of clay. In most respects the subsoils are similar to the surface soils. The underlying substratum is a loose unconsolidated mass of soil material laid down by flowing water. The surface soils and the subsoils are slightly basic and have a fair or low content of organic matter.

The Honcut soils have an alluvial origin, as the soil material represents outwash from the hills where the parent material is mainly fine-textured basic igneous rocks. They occupy gently sloping alluvial fans in narrow valleys in the hills and are subject to more or less cutting and filling during heavy storms. Drainage is excellent. The native cover consisted of short grasses and herbaceous plants, together with oaks, all of which have been cut for fuel. These soils do not contain injurious accumulations of alkali.

The Honcut soils were included in the Hanford series of the earlier reconnaissance surveys (*4*, *7*), as they are inextensive. They differ from the Hanford soils chiefly in their mineralogical composition. As mapped in this area, these soils are developed under lower rainfall, are lighter in color, and have a more basic reaction than the Honcut soils along the eastern part of the Sacramento Valley. Honcut loam is the only type mapped in this area.

**Honcut loam.**—Honcut loam has a surface soil of brown loam that grades into light-brown loam or fine sandy loam. The subsoil is devoid of any consistent compaction or accumulation of clay and is similar to the surface soil, except that it is somewhat lighter

colored. The underlying substratum is a loose unconsolidated mass of soil material that has been deposited by flowing water. The entire soil mass contains small angular fragments of schistose rock material, which are not numerous enough to interfere with cultivation or the moisture-holding properties of the soil. This soil has a fair to low content of organic matter, is well drained, and does not contain injurious alkali salts. It absorbs water readily and is easy to till.

This soil occupies gently sloping alluvial fans in narrow valleys along the edge of the foothills, where it is subject to overflow during heavy rains. Only a very small total area is mapped. One small body along the northern edge of the area, about 3 miles southeast of Strathmore, differs from the typical soil in having a calcareous subsoil. Honcut loam is an excellent soil for a wide range of crops when irrigated, but it is subject to overflow, which may cause considerable damage to crops.

### FOSTER SERIES

The soils of the Foster series consist of recent alluvial deposits, coming mainly from granitic sources. The surface soils are dull gray or dark brownish gray, are micaceous, and contain a fair amount of organic matter. In most places lime is present in disseminated form. The surface soils are loose and friable and tend toward a single-grain structure. The subsoil generally are somewhat lighter colored than the surface soils, being light brownish gray or grayish brown. In some places the subsoils are mottled, indicating an earlier period of poor drainage, but at present drainage is good, as the water table has been lowered by pumping for irrigation. Lime is generally present in slightly larger quantity than in the surface soils. The textures are similar to the surface soils except where stratification occurs. The substratum resembles the subsoil, but in some places it represents old valley-filling material similar to the Madera soils, over which the Foster soil material has been superimposed.

The Foster soils in this area occur on the fans of the Tule River and Deer Creek. The surface is smooth and uniform, and drainage of the surface soil and subsoil is good. Foster fine sandy loam, shallow phase (over Madera soil material), contains a slight to moderate amount of alkali in spots. The native vegetatioin consists of grasses, such as foxtail, squirreltail, and needlegrass, and some alfileria, also valley oaks, willows, and cottonwoods along drainageways. In this area the Foster soils are associated mainly with the Cajon soils, which are light grayish-brown recent alluvial calcareous soils from granitic sources occurring on the same relief, but under somewhat better drainage conditions, and they are lighter in color. The Foster soils are associated also with the Chino soils, which have heavy subsoils and a slight accumulation of lime.

Three types and one phase are mapped—Foster loamy sand, Foster fine sandy loam, Foster loam, and Foster fine sandy loam, shallow phase (over Madera soil material). Foster fine sandy loam and Foster fine sandy loam, shallow phase (over Madera soil material), are the most extensive. They occur west of Porterville and around Woodville. About 29 percent of Foster fine sandy loam, shallow

phase (over Madera soil material), contains alkali, but the typical soil and Foster loamy sand are relatively free from alkali where drainage is good. Most areas of the Foster soils are fairly productive and are used for a large variety of crops. Field crops consist mainly of corn, cotton, sorghum, and truck crops, and the principal deciduous fruits are peaches, apricots, and prunes.

**Foster loamy sand.**—The surface soil of Foster loamy sand is dark brownish-gray or dark-gray micaceous friable slightly calcareous loamy sand to a depth ranging from 10 to 20 inches. When the material is moistened its color becomes darker, thus differing from the corresponding material of the Cajon soils, which are lighter in color and become more brown when moist. The surface soil contains a fair quantity of organic matter, more so than do the surface soils of the Hanford or Cajon soils. The subsoil is slightly lighter in color than the surface soil and is slightly mottled with iron stains. It is loose, friable, calcareous, and micaceous; and the texture ranges from slightly coarser to slightly heavier than that of the surface soil. It is stratified in places. The lower part of the subsoil commonly contains slightly more lime than the upper part. The lime is in disseminated form. The substratum is similar to the subsoil in texture and likewise is loose, friable, and micaceous.

Most of this soil occurs within a radius of 2 miles of Woodville and is closely associated with Foster fine sandy loam, Foster fine sandy loam, shallow phase (over Madera soil material), and Cajon sandy loam.

Foster loamy sand is developed from granitic parent material that has been transported by the Tule River and deposited on the lower, flatter parts of alluvial fans and outwash flood plains. This soil is of recent accumulation and shows very little evidence of the development of a profile.

No stones or gravel occur to hinder cultivation, and the very friable and loose loamy sandy surface soil can be cultivated everywhere. The water-holding capacity of this soil is not high, but the quantity of organic material present is an aid to its water-holding capacity. This soil has the flat, smooth surface of the lower alluvial fans. Surface drainage is good, and the soil is free of alkali and is well adapted to irrigation. It is irrigated and planted mainly to cotton, with some alfalfa, grain, and grapes, from which good yields are obtained.

**Foster fine sandy loam.**—The surface soil of Foster fine sandy loam, to a depth ranging from 18 to 24 inches, is dull-gray or dark brownish-gray calcareous micaceous loose friable fine sandy loam. The lime is disseminated, with no evidence of accumulation in seams or nodules. The subsoil generally is lighter in color—grayish brown or light grayish brown—when dry, and darker when wet. The texture varies somewhat, owing to stratification; but in most places the subsoil is similar to the surface soil, is friable and micaceous, and contains an increasing quantity of lime with depth. It is mottled to some extent with iron stains, reflecting a condition of poor drainage at some past time. The underlying substratum is similar to the subsoil in texture, color, and lime content. The surface soil contains a moderate quantity of organic material and when moist becomes darker.

Foster fine sandy loam is a recent alluvial soil having its source mainly in granitic material, which has been transported from the Sierra Nevada foothills by the Tule River and Deer Creek and deposited on the lower part of the alluvial fans and flood plains. This soil has a flat, smooth surface, making it favorable for irrigated crops, and has good surface drainage. At present, owing to the lowered water table, subsoil drainage is good. None of the fine sandy loam is seriously affected by alkali, although a slightly spotted condition occurs where drainage is somewhat poorer. This soil is easily tilled, being friable to its full depth under all conditions. It is used for a large variety of crops, including corn, cotton, sorghum, and truck crops. Prunes, peaches, and apricots are the important deciduous fruits grown. The largest bodies of this soil extend northeast and southwest of the town of Poplar and northwest toward Woodville; and small bodies are in the northern part of the area. This is an ideal soil for most truck and deciduous fruit crops because of its good water-holding capacity, ease of tillage, and good surface and subsoil drainage.

**Foster fine sandy loam, shallow phase (over Madera soil material).**—The surface soil of this phase is similar to the typical soil in most places, although in some areas it is slightly heavier in texture. Generally, it is underlain abruptly, at a depth ranging from 12 to 36 inches, by brown heavier textured soil material, which, at a depth ranging from 2 to 4 feet, rests on a brown or dark reddish-brown calcareous platy and fairly soft hardpan. In most of the areas of this shallow soil the underlying soil and hardpan material appear to represent material of the Madera soils, over which the alluvial Foster material has been superimposed. In some of the areas, however, especially in the vicinity of the northern boundary of the survey, which joins the Visalia area (*9*), the underlying material is grayer and the hardpan is more highly calcareous and softer and is more representative of buried material of the Fresno series. In a few places the surface soil of the older buried soil has been eroded away, leaving the hardpan directly beneath the Foster fine sandy loam material.

In most places the surface is smooth and flat, as in the typical soil; but in some places—as in the area 2½ miles northeast of Woodville—a few hog wallows are present. The subsoil drainage is poor, owing to the presence of the hardpan layer; and some of this soil, especially in the areas of grayer soil, contains a slight to moderate amount of alkali. Of the total area mapped, about 71 percent is free of salts, 13 percent contains a slight amount, and 16 percent a moderate amount.

The largest area of this soil is 1½ miles south of Woodville and extends to the west for a distance of 2 miles. The southern part of this body contains a slight amount of alkali. A small body 2¼ miles southwest of Woodville and one 4 miles northeast of Woodville contain a moderate amount of salts. About 1 square mile, free of alkali, is near Sausalito School.

This soil is used for pasture and cotton, together with some alfalfa, mainly in connection with dairying. The soil is too shallow and poorly drained for fruits.

**Foster loam.**—Foster loam is very similar to Foster fine sandy loam in color and profile, but it is heavier textured. It has a slightly higher content of lime in the subsoil, and, because of slightly poorer drainage, it is more mottled with iron stains than that soil. Only a small total area is mapped, of which about 89 percent is free of alkali and 11 percent contains a slight amount of salts. Several small areas are near Woodville; others are north of Success, near Deer Creek close to the eastern boundary of the area, and southeast of South Tule School. A small area containing a slight amount of salts is 3 miles northwest of Tipton. This soil is used mainly for cotton, some truck crops, and deciduous fruits.

### CAJON SERIES

The surface soils of members of the Cajon series are light brownish gray or light grayish brown. When wet they appear light brown, in places with a yellow tint. They are very friable, very permeable to roots and water, and largely of single-grain structure. They are highly micaceous, are slightly or moderately calcareous, and contain a small quantity of organic matter. The subsoils are very similar to the surface soils and show no compaction or accumulation of clay or colloids. In places they contain somewhat more lime, which is in disseminated form, than do the surface soils, but they show no concentration in the form of nodules or seams. The color is somewhat lighter or more yellowish gray than that of the surface soils. The substratum, to a depth of several feet, is similar to the subsoils. Both the subsoils and the substratum are stratified in places, and coarse-textured sandy or gravelly layers commonly occur in the lower part of the subsoil or in the substratum.

The Cajon soils consist of recent alluvial sediments transported and deposited by the rivers and creeks flowing out of the foothills and mountains east of the area. The soil materials have been derived mainly from granitic rocks and the granitic Vista soils. These soils occur on the recent alluvial flood plains and broad flat gently sloping alluvial fans of the Tule River, the White River, and Deer Creek. They are generally free from overflow, but a few of the areas adjacent to the streams are subject to floods during seasons of heavy rainfall. Surface drainage and subdrainage are excellent at present, although a few rust-brown mottlings in the lower part of the subsoil indicate that a relatively high water table may have been present at some earlier period. Excessive pumping since irrigation began has lowered the water table to a depth ranging from 20 to 80 feet.

About 35 percent of the Cajon soils contain a slight to medium amount of alkali. This commonly consists of saline salts, although some black alkali is present in places. The native vegetation consisted largely of grasses, oaks, cottonwoods, and shrubs.

The Cajon soils are associated with and related to the Tujunga, Hanford, and Foster soils, from which they differ in being calcareous, and from the Foster soils in having a lighter and more brown color and a lower organic-matter content.

These soils were included largely in the Hanford series in the older reconnaissance surveys of this region (*4*, *7*). Where alkali or saline

salts are not present in harmful amounts, these are good to excellent soils, adapted to a wide range of crops. Cajon sandy loam and Cajon fine sandy loam, both with shallow phases, occur in this area.

**Cajon sandy loam.**—The surface soil of Cajon sandy loam, to a depth of 10 to 15 inches, is light grayish-brown or light brownish-gray sandy loam, which appears light brown or light yellowish brown when wet. The subsoil is light brownish-gray, in places slightly yellowish gray, sandy loam or coarse sandy loam. It is very similar to the surface soil and shows no compaction or development of a heavier textured layer. The substratum, to considerable depth, is similar to the subsoil. Both the subsoil and the substratum are stratified in places with material generally as coarse as or coarser than sandy loam. The entire soil mass contains much mica and somewhat angular quartz grains. This soil consists of recent alluvial materials transported and deposited by the streams flowing out of the Sierra Nevada and foothills.

The entire soil mass is extremely friable, somewhat loose, single grain in structure, and readily permeable to roots to considerable depth. In places the surface soil may pack somewhat when dry, but not enough to prevent easy tillage operations. Water is absorbed readily, but the water-holding capacity is rather low, necessitating frequent irrigations.

The entire soil material is slightly or moderately calcareous, although in a few areas where the surface soil is coarser in texture than typical the material does not effervesce, or effervesces only very slightly, when treated with dilute hydrochloric acid. About 6 percent of this soil contains a small quantity of alkali, consisting mostly of soluble chlorides and sulfates, although in places some sodium carbonate and sodium bicarbonate are present. Most of these alkali areas have a saltgrass vegetation. The organic-matter and nitrogen contents are very low, but sufficient quantities of other plant nutrients for ordinary crops seem to be present. Applying barnyard manure or plowing under green-manure crops is very beneficial in increasing the water-holding capacity and the organic-matter content of the soil.

This soil occurs as narrow areas on recent alluvial flood plains of the Tule and White Rivers and Deer Creek. It usually is free from overflow, but a few areas are subject to flood during brief periods of heavy rainfall. These areas are the only ones where any erosion occurs, and even here erosion results only from the washing out of new channels. Except for brief and infrequent periods, surface and internal drainage are excellent.

The largest areas of this soil are east of Porterville and south of Woodville. Small areas of Cajon coarse sandy loam and Cajon loamy sand are included with this soil in mapping because of their small extent. The relatively large area immediately south of Woodville is largely loamy sand or coarse sandy loam, and the surface soil contains a smaller quantity of lime than is typical of Cajon sandy loam. This soil is associated with Tujunga sand, Cajon fine sandy loam, and Foster loamy sand.

The native vegetation consisted of grasses, oaks, willows, cottonwoods, and shrubs. Approximately 95 percent of this soil is cleared, and most of it is in cultivation. Where sufficient water is available and

no injurious salt accumulations are present, it is adapted to a wide variety of crops. Grapes are the principal crop grown, and good to excellent yields are obtained. Other crops are cotton, alfalfa, peaches, apricots, prunes, grain, and vegetables. Irrigation is necessary for all cultivated crops, except where grain is dry-farmed.

**Cajon sandy loam, shallow phase (over Madera soil material).**—This soil has a surface soil, ranging from 24 to 48 inches in thickness, consisting of light grayish-brown or light brownish-gray sandy loam that is loose, very friable, micaceous, and slightly to moderately calcareous. The texture varies considerably from sandy loam to loamy fine sand or loamy sand. Where its texture is coarse, the soil in places is noncalcareous or only very slightly calcareous. This material rests abruptly on light-brown or reddish-brown slightly or moderately compact clay loam, which contains much lime in the form of soft nodules or seams and ranges from 6 to 24 inches in thickness. This layer overlies a reddish-brown or brown calcareous impermeable hardpan, from 12 to 24 inches thick. Below this, the material consists of fairly loose and friable sandy loam.

This soil represents a comparatively recent overwash of material similar to Cajon sandy loam, which has been deposited over an older soil similar to the Madera soils. It occupies relatively narrow old stream ridges or channels and has a flat or gently sloping surface. Surface drainage is excellent, but subdrainage is restricted by the indurated hardpan horizon. None of the land is flooded or subject to erosion, and no evidence of alkali is present.

This is an inextensive soil, and practically all of it occurs southeast and north of Poplar. It is used largely for cotton and grain. The presence of the hardpan layer and the coarse texture of the soil are the restrictive factors in crop production.

**Cajon sandy loam, shallow phase (over Chino soil material).**—The surface soil of this phase consists of light grayish-brown or light brownish-gray sandy loam with minor inclusions in texture, ranging from loamy fine sand to loamy sand. The material in this layer is rather loose, very friable, single grain in structure, and slightly to moderately calcareous. Some of the areas of the coarser textured soil are noncalcareous or only very slightly calcareous. At a depth ranging from 12 to 42 inches, this material rests on medium dark-gray or slightly dark brownish-gray heavy loam or clay loam that is slightly compact and moderately calcareous. This layer is about 8 inches thick and grades into a layer that is lighter and more brown in color, slightly more compact and dense, somewhat heavier in texture, and contains an accumulation of lime in the form of seams and soft nodules. This rests on a substratum of light brownish-gray calcareous friable loam or fine sandy loam. The entire soil material is micaceous.

This soil represents a comparatively recent overwash of material similar to Cajon sandy loam, which has been deposited by overflow from the Tule River over an older soil that is similar to the Chino soils. It has a smooth, gently sloping relief. Surface drainage is excellent, and subdrainage in most places is good. None of the land is flooded, and none is subject to erosion. About 4 percent of this soil contains a slight quantity of alkali.

The larger areas are in the vicinity of Woodville, and there are bodies north of Tipton and northwest of Porterville. This soil is associated with Cajon sandy loam, Cajon fine sandy loam, Chino fine sandy loam, and Chino loam. All the land is cleared; about 75 percent is cultivated, and the rest is in pasture. The principal crops—cotton, grain, and alfalfa—all return good to excellent yields.

**Cajon fine sandy loam.**—The surface soil of Cajon fine sandy loam, to a depth of 10 to 15 inches, is light grayish-brown smooth fine sandy loam in which the gray color may be very pronounced when dry. As mapped some small areas of lighter loamy fine sand texture may be included. The subsoil is light brownish gray, which may appear slightly yellowish gray when moist, and is very similar to the surface soil, but without consistent compaction or accumulation of clay or colloids. The substratum, to a depth of several feet, is similar to the subsoil, and both the subsoil and the substratum may be stratified and of variable texture, in places including loose sand or gravelly layers. The entire soil material is highly micaceous.

This soil has been formed by the deposition of alluvial materials during floods on the alluvial flood plains and alluvial fans of the rivers and creeks flowing from the mountains and hills on the east. The entire soil mass is extremely friable, somewhat loose in structure, readily penetrated by water and roots, and easy to till. It has a moderate water-holding capacity, and a high percentage of the water held is available to plants. Both the surface soil and the subsoil are moderately calcareous, although a few areas are included in which the surface soil does not effervesce when treated with dilute hydrochloric acid. The organic-matter and nitrogen contents are moderately low, but sufficient quantities of other plant nutrients seem to be present for the production of the crops commonly grown. Applications of barnyard and green manures are very beneficial in increasing the organic-matter and nitrogen contents and the water-holding capacity.

About 15 percent of this soil contains a slight quantity of alkali, and approximately 2 percent contains a medium quantity of salts commonly consisting of white alkali. In a few places black alkali is present. Most of the alkali areas have a saltgrass cover.

This soil occurs on the alluvial flood plains and the alluvial fans of the rivers and creeks flowing from the mountains on the east. The land is smooth and gently sloping and lies favorably for irrigation. A few areas adjacent to rivers or stream channels are subject to floods, which are infrequent. Surface drainage and subdrainage are now excellent, although some rust-brown mottlings in the lower part of the subsoil indicate imperfect drainage or a high ground-water table at some time in the past. The ground-water level has been materially lowered by pumping for irrigation and is gradually receding under most of the areas.

A fairly large total area of Cajon fine sandy loam is mapped. The more extensive bodies are west of Porterville and southwest of Poplar on the alluvial fan of the Tule River. Smaller areas occur in the alluvial valleys of the Tule River and on the alluvial fan of Deer Creek. The soil in a few areas in the vicinity of Woodville and Poplar is slightly dull or darker than the typical Cajon soil but not

so dark as Foster fine sandy loam. This soil is commonly associated with Cajon sandy loam, Foster fine sandy loam, and Traver fine sandy loam.

About 95 percent of this soil is cleared of its native vegetation. More than 75 percent of the cleared land is in cultivation, and the rest is in pasture. Except where alkali is present, the soil is well adapted to a wide variety of crops and good yields generally are produced. Cotton is the principal crop, yields of which range from 1½ to 2½ bales an acre and average about 2 bales. Other important crops are alfalfa, peaches, apricots, prunes, barley, and wheat. Small acreages are devoted to grapes, oats, onions, asparagus, and other vegetables.

**Cajon fine sandy loam, shallow phase (over Madera soil material).**—To a depth ranging from 18 to 40 inches, this soil consists of light brownish-gray or light grayish-brown fine sandy loam that is smooth, friable, slightly or moderately calcareous, and micaceous. The lower part of this layer is lighter colored than the upper part and in places consists of stratified materials. This layer rests abruptly on light-brown, reddish-brown, or somewhat dark grayish-brown calcareous slightly compact loam, about 6 inches thick. This grades into reddish-brown or light-brown somewhat compact and slightly dense clay loam, which contains an accumulation of lime in the form of seams or soft nodules and is from 12 to 18 inches in thickness. This, in turn, rests on a reddish-brown or brown calcareous hardpan from 12 to 24 inches in thickness. The substratum below the hardpan consists of loose friable sandy loam.

This soil represents an overwash of typical Cajon fine sandy loam material on an older Maderalike soil. It occurs under similar conditions and on similar relief as typical Cajon fine sandy loam. Subdrainage is restricted by the presence of the indurated hardpan. About 4 percent of this soil contains a small quantity of salts.

The most extensive area is just north and northwest of Porterville; several bodies are on the alluvial fan of the Tule River west of Porterville and east of Woodville and on the alluvial fan of Deer Creek southwest and west of Sausalito School. This soil is well adapted to a wide variety of crops, except where alkali is present or where the hardpan layer is too near the surface. About 30 percent of the land is used for pasture, and the rest is cultivated. The principal crop is cotton, which returns good yields. Other crops are alfalfa, deciduous fruits, grain, asparagus, and other vegetables.

**Cajon fine sandy loam, shallow phase (over Pond soil material).**—This soil consists of light brownish-gray or light grayish-brown smooth friable slightly to moderately calcareous fine sandy loam to a depth ranging from 10 to 15 inches. Beneath this layer the soil becomes slightly lighter in color but is otherwise similar to the surface soil. At a depth ranging from 3 to 5 feet, this material rests on light brownish-gray or slightly yellowish gray somewhat compact loam or light clay loam, from 1½ to 3 feet in thickness, which contains some accumulation of lime, commonly in the form of seams and soft nodules. This is underlain by a light yellowish-gray more friable calcareous substratum of sandy loam or fine sandy loam texture. The entire soil material is micaceous.

This soil represents an overwash of Cajon fine sandy loam material over an older soil similar to the members of the Pond series. The surface soil of the buried Pond soil is present in places and absent in others. This soil occurs under similar conditions and on similar relief as typical Cajon fine sandy loam. Subdrainage is slightly restricted by the more compact lower subsoil layer. All the soil contains a slight quantity of salts, including the black alkali, most of which occurs in the more compact lower subsoil layer.

Cajon fine sandy loam, shallow phase (over Pond soil material), is relatively inextensive. It occurs chiefly south, southeast, and east of Tipton. It is associated with Cajon fine sandy loam, Traver fine sandy loam, Hesperia sandy loam, and Tujunga sand.

About 60 percent of this soil is cultivated, and the rest is used for pasture. Cotton, grain, and alfalfa are the principal crops, yields of which range from fair to good, depending largely on the salt content of the soil. Irrigation is necessary for all crops except winter-grown grain. Water is obtained by pumping from wells.

### GREENFIELD SERIES

The Greenfield soils have light grayish-brown or brown sandy surface soils, light-brown or rich-brown upper subsoil layers, and light yellowish-brown lower subsoil layers of similar texture. Both the surface soils and the subsoils are noncalcareous and do not effervesce with hydrochloric acid. A slightly compact but permeable layer, about 2 feet thick, occurs at a depth ranging from 2 to 4 feet. These soils are developed from transported material, mainly of granitic origin, on alluvial fans. They are most closely related to and are associated with the Hanford soils. They are developed on similar parent materials but represent a slightly advanced stage in profile development. The Greenfield soils are well drained and free from alkali. The native vegetation consists of grass and associated flowering plants. Only one type, Greenfield sandy loam, is recognized in this area.

**Greenfield sandy loam.**—The surface soil of Greenfield sandy loam is light-brown friable sandy loam to an average depth of 12 inches. It contains much coarse sand, which gives it a gritty feel, and enough fine-textured material to make it coherent and slightly sticky when moist. The upper part of the subsoil, to a depth of about 36 inches, is light yellowish-brown or grayish-brown very slightly compact sandy loam. This is underlain by a zone of maximum compaction, consisting of yellowish-brown or pale reddish-brown slightly compact sandy loam. This material breaks up into small blocks that pulverize easily. It is underlain by light yellowish-brown or brown friable sandy loam. The surface soil and the subsoil are noncalcareous and do not effervesce with hydrochloric acid. Much coarse quartz sand and considerable mica is in the surface soil and in the upper part of the subsoil.

This soil is easy to farm and has a good water-holding capacity. It is well drained and free from alkali. The larger areas have a smooth surface with a gentle slope to the west, but some of the smaller areas near streams occupy eroded terraces. Most of this

soil is in one large area west of Richgrove; smaller bodies are in the southeastern part of the area, mainly southeast of Terra Bella.

Probably 85 percent of the land is under cultivation, and the rest is used for pasture. About 30 percent of the cultivated area, chiefly near the Sierra Vista ranch, is used for grapes. Most of the soil farther east, or about 35 percent of the cultivated area, is devoted to dry-farmed wheat, which yields about 10 or 12 bushels an acre, or slightly less than that grown on the Ducor and Exeter soils. The land is fallowed in alternate years. Other areas are used largely for cotton and truck crops.

### HESPERIA SERIES

The Hesperia soils have grayish-brown surface soils and light yellowish-brown or light grayish-brown friable subsoils. The surface soils and upper parts of the subsoils are noncalcareous to an average depth of 18 inches, but the lower parts of the subsoils effervesce with dilute acid. Little difference in appearance is noted between the noncalcareous and the calcareous layers, but the subsoils are very slightly compact in places between depths of 20 and 36 inches. Below a depth of 36 inches the subsoils are lighter colored, single-grained, friable sandy material. These soils resemble the Hanford soils except in having calcareous lower subsoil layers and somewhat older, more developed profiles. They differ from the Greenfield soils of this survey in having subsoils that are less compact in the upper part and calcareous in the lower part. The parent material is derived mostly from granite and contains considerable mica.

The largest areas of these soils are on the outer borders of alluvial fans in a belt south of Tipton, between the Pond soils to the west and the Hanford soils to the east. Surface drainage and underdrainage are good in most areas. The land is smooth with a gentle westward slope and is well suited to irrigation.

Most of the Hesperia soils are free from injurious accumulations of alkali. The native vegetation consists of grass and associated flowering plants. Two types of the Hesperia series, the sandy loam and the loam, are recognized in this area. They are productive soils, slightly lower in value than the Hanford soils.

**Hesperia sandy loam.**—The surface soil of Hesperia sandy loam is light grayish-brown (gray when dry) sandy loam to an average depth of about 12 inches. It contains some granitic coarse sand, which gives it a gritty feel, and enough fine-textured material to make it coherent when moist. Considerable mica is in the entire soil mass. The upper part of the subsoil, between depths of 12 and 24 inches, is light grayish-brown or yellowish-brown noncalcareous sandy loam or fine sandy loam with a single-grain structure. At a depth of about 20 inches it becomes calcareous and very slightly compact or more coherent, although of the same texture as the material above, and contains a small quantity of finely disseminated lime. At an average depth of 40 inches this material grades into pale yellowish-brown faintly calcareous less coherent sandy loam, which continues to a depth of more than 72 inches.

Areas of this soil contiguous to Hanford sandy loam have little or no compaction in the subsoil and in places are noncalcareous to a depth

of 5 feet. Areas bordering the Pond soils have a slightly compact subsoil below a depth of 12 inches. The organic-matter content is low. Most areas are fairly free from alkali, but a few areas contain a small quantity of salts, and alkali areas are more numerous than in Hanford sandy loam. The surface is ideal for irrigation. Large areas of this soil are between Earlimart and Tipton.

It is estimated that 70 percent of this soil is under cultivation, and the rest is used for pasture, owing to the shortage or the high cost of water for irrigation. Nearly all of the land has been plowed at some time. This soil is not used for dry farming. Probably 40 percent of the cultivated area is used mainly for truck crops, 25 percent for grapes, and the rest for cotton, alfalfa, fruit trees, and some grain, mostly cut for hay. The soil is especially well adapted to truck crops. Head lettuce, cantaloups, tomatoes, and the Telephone variety of peas are the most common, but nearly all vegetables are grown. The acreage devoted to grapes is increasing rapidly, and in this area this soil ranks next to Hanford sandy loam in its adaptability to grapes.

**Hesperia loam.**—The surface soil of Hesperia loam is brown or grayish-brown loam to an average depth of about 14 inches. The soil contains considerable coarse sand, but it is rather sticky when moist and very hard when dry. This material grades into lighter brown loam that is friable but slightly compact when moist and rather compact when dry, and the texture becomes coarser with depth. At a depth of about 48 inches, this, in turn, grades into yellowish-brown calcareous fine sandy loam or sandy loam containing some rust-brown and limonite-yellow mottlings. The structure of the material in this layer is faintly cloddy.

This soil occurs on nearly level land, but many areas are in slight swales. Surface drainage is slightly restricted but is sufficient for this region of low rainfall; underdrainage is very good.

Probably 70 percent of this soil is cultivated every year, and the rest is used for pasture. The same crops are grown as on Hesperia sandy loam, but less grapes and more cotton are grown on this soil, probably 25 percent of the cultivated area being devoted to cotton and 10 percent to grapes.

A few areas having a very fine sandy loam or fine sandy loam surface soil are included with this soil in mapping, owing to their similarity and small extent.

The total area of Hesperia loam, although less than that of the sandy loam, is fairly large. The soil occurs chiefly southeast of Earlimart.

### CHINO SERIES

The surface soils of the members of the Chino series range from dark gray to slightly dark brownish gray that appears considerably darker, in places nearly black, when the soils are wet. They are micaceous, slightly or moderately calcareous, somewhat granular in structure, and generally very friable. Earthworm holes and casts are numerous. The heavier textured types are moderately plastic when wet and cloddy when dry. The organic-matter content is relatively high. Beginning at a depth of 10 to 16 inches, the subsoils are lighter colored than the surface soils, ranging from medium

dark gray to brownish gray. Compared with the surface layer, the subsoil layer is heavier in texture, slightly more compact and dense, and slightly more calcareous, the lime commonly being segregated in small seams. A nut to small-clod structure is slightly developed in most places. The material is rather friable and very permeable to roots and water. At a depth ranging from 20 to 30 inches the color becomes slightly dark brownish gray or light brownish gray that appears considerably more brown when crushed. A few mottlings of dark gray, light gray, or yellow are present in places. The material is moderately compact, is dense, and generally breaks into large somewhat rounded clods. The texture ranges from light clay loam to clay. Considerable lime is present in the form of soft nodules and seams. At a depth ranging from 40 to 50 inches this material grades into a light grayish-brown, light yellowish-gray, or light brownish-gray somewhat mottled friable permeable sandy loam or loam substratum, which generally has a single-grain structure and contains less lime than the layer above.

The Chino soils represent a young stage in profile development. They have developed on alluvial material that was derived largely from granitic sources, transported by the rivers and creeks flowing out of the Sierra Nevada and foothills, and deposited on alluvial fans. They occupy smooth, very gently sloping areas on the outer parts of the alluvial fans of the Tule and Kaweah Rivers and Deer Creek. These soils are not subject to erosion, and surface drainage is now generally fair to good, but subdrainage is restricted somewhat because of the heavier textured, denser subsoils. Under virgin conditions the water table was high and much of the area of these soils was under water for considerable periods during the wet seasons. Approximately 55 percent of these soils contains slight to moderate amounts of alkali, generally saline salts. The native vegetation consisted largely of grasses and a few scattered oaks.

The Chino soils are associated with soils of the Foster and Pond series. They differ from the Foster soils in having subsoils that are slightly or moderately heavier and more dense than the surface soils and that also contain an accumulation of lime in the form of soft nodules or seams. They differ from the Pond soils in having darker colored surface soils with a higher content of organic matter and a generally smaller content of alkali. Where free of alkali, these soils are well adapted to general farm crops.

In this area, Chino fine sandy loam; Chino sandy loam; Chino loam; Chino loam, shallow phase (over Madera soil material); Chino clay loam; and Chino clay loam, shallow phase (over Fresno soil material), are mapped.

**Chino fine sandy loam.**—The surface soil of Chino fine sandy loam, to a depth ranging from 10 to 20 inches, is medium or slightly dark gray, with a slight brown cast, and becomes more brown and considerably darker when wet. It is smooth, friable, micaceous, calcareous fine sandy loam, somewhat cloddy when dry. The upper subsoil layer is somewhat lighter and more brown than the surface soil and contains a slight accumulation of lime in seams. The lower subsoil layer, extending to a depth of about 50 inches, is medium dark brownish-gray loam or light clay loam, generally mottled with gray-

ish brown. In a few places the color is light grayish brown. The material is fairly compact and slightly dense, breaks into large rounded aggregates, and contains much accumulated lime in the form of soft nodules or seams. The substratum consists of light brownish-gray or light grayish-brown micaceous calcareous loam or fine sandy loam continuing to considerable depth. The material in all layers is highly micaceous. This soil is developed on alluvial outwash material derived from granitic sources.

The surface soil is easy to till and absorbs water readily, and the subsoil is rather easily penetrated by both water and roots. The water-holding capacity is moderate, and the organic-matter and nitrogen contents are moderately high. About 2 percent of the total area of this soil contains a small quantity of alkali, and some small alkali spots occur in places. The salts are generally of the white alkali or saline kind. The areas containing alkali generally have a saltgrass cover.

This soil occurs on the smooth alluvial fans of the Tule River and Deer Creek, which are favorable to irrigation. It is generally free from erosion, and none of the land is flooded. Surface drainage is good, and subdrainage is somewhat restricted, although generally adequate. At present the ground-water level is at a depth ranging from 50 to 80 feet, although about 50 years ago it was near the surface during a large part of the year and drainage was inadequate.

Small, scattered areas of this soil occur largely within a radius of 6 miles of Woodville, and several bodies are within 2 miles south and about 2½ miles west of Sausalito School. This soil is associated with Foster fine sandy loam, the Traver and Cajon soils, and other soils of the Chino series.

This soil includes small areas of a lighter colored soil, very similar to Traver fine sandy loam. These areas are too small to differentiate on the map. Where associated with the Foster soils, the soil included in mapping is transitional, having only a very slightly developed subsoil, which is only very slightly heavier or more compact and dense than the surface soil. This inclusion has an accumulation of lime. Southwest of Poplar, the areas mapped as Chino fine sandy loam include a soil with a noncalcareous surface soil from 10 to 15 inches thick.

The native vegetation consisted largely of grasses and herbaceous plants, together with a few oaks and cottonwoods. Practically all of this soil is in cultivation, and only a small percentage of it is used for pasture. Cotton, the most important crop, is well adapted to this soil where free from excessive accumulations of salts. The yields range from 1½ to 2½ bales an acre. Other important crops are alfalfa and grain, especially oats and wheat. Most of the land is irrigated, especially for cotton and alfalfa.

**Chino sandy loam.**—The surface soil of Chino sandy loam consists of medium or slightly dark brownish-gray loose micaceous commonly slightly calcareous light-textured sandy loam. At a depth ranging from 15 to 30 inches this is underlain by slightly dark brownish-gray or grayish-brown micaceous somewhat compact and slightly dense loam or heavy loam, with considerable accumulation of lime in seams. The substratum below this, beginning at a depth ranging from 40

to 50 inches and continuing to considerable depth, consists of light grayish-brown friable micaceous slightly calcareous fine sandy loam. Some of the areas appear to represent an overwash of Foster sandy loam or loamy sand over a Chinolike subsoil.

The surface soil is porous and is readily penetrated by roots and water, but it has a low water-holding capacity. The subsoil is very permeable but is more retentive of moisture than the surface soil. The organic-matter content is moderate, and no alkali is evident in any of the soil material.

In most places this soil occupies gently sloping narrow sandy ridges probably built up by old stream courses. None of the land is subject to erosion or overflow, and drainage is good. A small area is mapped, principally southwest of Poplar and in the vicinity of Woodville, in association with Chino fine sandy loam, Foster loamy sand, Foster fine sandy loam, and Cajon sandy loam.

The native vegetation consists largely of grasses and associated herbaceous plants, with a few scattered oaks. Practically all of the land is in cultivation, and the principal crops are cotton, grain, and grapes. A small acreage is used for pasture. Because of the light-textured, porous, and droughty character of the surface soil, yields are appreciably lower than on Chino fine sandy loam. The land is irrigated for all cultivated crops except grain.

**Chino loam.**—The surface soil of Chino loam is medium or slightly dark gray, with a slight brown cast, becoming considerably darker when wet. It is friable smooth somewhat granular slightly or moderately calcareous loam containing much very fine sand and fine sand. At a depth ranging from 8 to 18 inches this material grades into light-brown smooth slightly compact loam or light clay loam, which breaks into indistinct rounded aggregates. It is calcareous and contains a few lime seams or soft nodules. At a depth ranging from 20 to 30 inches this layer grades into slightly dark brownish-gray or light grayish-brown clay loam or silty clay loam that is generally somewhat mottled with shades of yellow. The material in this layer is moderately compact and dense but breaks easily into large rounded clods. Considerable lime is present in the form of soft nodules and seams. The substratum, beginning at a depth of 45 to 60 inches and extending to an undetermined depth, consists of light grayish-brown, rust-brown, or yellowish-brown fairly friable sandy loam or loam, which becomes coarser with depth. It is slightly calcareous, and the content of lime decreases with depth. The entire soil material is highly micaceous. This soil has only a slightly developed profile and is formed on outwash material derived largely from granitic sources.

The surface soil is friable and easily tilled, although it becomes somewhat hard and tends to clod when dry. Both the surface soil and the subsoil are permeable to roots and water and are capable of retaining a large quantity of moisture. The organic-matter and nitrogen contents are moderately high, and the content of other plant nutrients is sufficient for ordinary crops. Approximately 53 percent of the total area contains a slight amount of alkali, about 15 percent contains a moderate amount, and about 32 percent is alkali-free or contains only a few small spots. The salts present generally consist of the chlorides

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and sulfates, although in places there is some sodium carbonate and bicarbonate.

This soil occurs on the outer parts of the alluvial fans in the northwestern part of the area, where it occupies a large total area. It occurs in smooth very gently sloping or flat areas favorable to irrigation. None of it is subject to erosion or floods. Surface drainage is generally good, and subdrainage is somewhat restricted by the heavier textured subsoil but in most places is adequate. The ground-water level has receded greatly during the last 25 years and now stands from 50 to 80 feet below the surface.

Chino loam is associated with Chino fine sandy loam, Chino clay loam, Foster fine sandy loam, Traver fine sandy loam, and Pond loam. Where associated with the latter two soils, it includes small areas of a lighter colored soil very much like Pond loam. These areas are too small to differentiate on the soil map.

The native vegetation consists largely of grasses and associated plants common to rather moderately drained areas, with a few scattered oaks. About 60 percent of the land is cultivated, and the rest is used for pasture. The cultivated areas are confined largely to those having no alkali or only a slight amount. The principal cultivated crops are cotton, grain, and alfalfa, which return good yields in places where the salt content is not too high and where plenty of water is applied. Small acreages are devoted to corn, milo, and deciduous fruits. All the cultivated land is irrigated, except where grain is grown. It supports a good growth of pasture grasses and is used largely for dairying, except where the content of alkali is high.

**Chino loam, shallow phase (over Madera soil material).**—The surface soil of this phase consists of medium-gray or slightly dark gray loam with a somewhat brown cast, which becomes considerably darker when wet. This material is friable, smooth, slightly granular, slightly or moderately calcareous, and micaceous. At a depth ranging from 8 to 18 inches it grades into a layer of slightly lighter and more brown, smooth, rather friable but slightly compact loam or light clay loam, which breaks into indistinct rounded aggregates. This material is calcareous and contains a few seams or soft nodules of lime in places. At a depth ranging from 20 to 30 inches the material in this layer grades into slightly dark brownish-gray or light brownish-gray somewhat mottled clay loam or silty clay loam. It is moderately compact or dense, breaks easily into large rounded clods, and contains an accumulation of lime in the form of soft nodules or seams. This, at a depth ranging from 30 to 38 inches, is underlain by light-brown or reddish-brown clay loam, which is slightly or moderately compact and contains an accumulation of lime in the form of seams and soft nodules. In places this layer is absent or very thin. It is underlain, at a depth ranging from 36 to 60 inches, by a brownish-red or reddish-brown hardpan, which becomes less red and more brown with depth. In most places a layer of accumulated lime, about one-sixteenth of an inch thick, immediately overlies the hardpan, which contains a few lime nodules. The hardpan ranges from 1 to 2 feet in thickness and rests on light yellowish-gray or light yellowish-brown loose sandy micaceous material of undetermined depth.

This soil represents a typically developed Chino surface soil and subsoil deposited over an older soil similar to the members of the Madera series. In most places the surface soil and in some places the subsoil of the older Madera soil is absent. In such places the Chino soil rests directly on the Madera hardpan.

This soil occurs under conditions similar to those pertaining to typical Chino loam. Subdrainage is inadequate because of the presence of the impervious and impermeable hardpan layer, but the hardpan is generally far enough below the surface not to interfere with root development of most plants. About 22 percent of this soil contains a small quantity of alkali.

Only a very small total area of this soil is mapped, practically all of which is from 1 to 4 miles east, southeast, and northeast of Woodville. It is associated with Chino loam, Madera loam, and Foster fine sandy loam, shallow phase (over Madera soil material). Practically all of the land is cultivated. The principal crops are cotton, alfalfa, and grain, and a small acreage is planted to deciduous fruits. Yields are comparable to those produced on typical Chino loam.

**Chino clay loam.**—The surface soil of Chino clay loam, to a depth of 10 or 12 inches, is dark-gray slightly calcareous micaceous somewhat friable clay loam that appears darker when wet. When dry it breaks into somewhat blocky or cloddy pieces, but it is slightly plastic when wet. It grades into a layer, about 10 inches thick, of lighter and more brown fairly compact clay loam that has an accumulation of lime in the form of soft nodules. The lower subsoil layer, to a depth of 25 to 35 inches, consists of brownish-gray or light brownish-gray compact and somewhat dense heavy clay loam or clay. This material contains a considerable accumulation of lime in the form of soft nodules, and it breaks easily into large rounded aggregates. It grades into light yellowish-gray, light-gray, or light yellowish-brown loam or fine sandy loam, which is somewhat compact in places but generally friable. This material has a massive structure and contains less lime than the layer above. The entire soil material contains some mica. This is a young soil developed on outwash material derived largely from granitic sources.

This soil is generally friable under favorable moisture conditions, but when worked under unfavorable moisture conditions it has a tendency to puddle or bake, cracks to some extent, and becomes rather hard when dry. The surface soil and the subsoil are permeable to roots, and the surface soil absorbs water fairly well except when it is puddled and baked or where it contains alkali. The water-holding capacity is high, the organic-matter and nitrogen contents are moderately high, and the material contains sufficient plant nutrients for ordinary crop production. Approximately 53 percent of this soil contains a moderate amount of alkali, about 24 percent contains a slight amount, and the rest is free from injurious salts or contains them only in small spots. The salts present generally are white alkali, although black alkali may occur in places, especially in the western part of the area.

This soil has a smooth, very gently sloping to flat surface that allows easy irrigation. Surface drainage is poor in a few slight

depressions, but in most places it is fair or good. Subdrainage is somewhat restricted by the heavier more compact subsoil but in most places is adequate. Under virgin conditions the ground-water level stood near the surface and much of the land remained under water for considerable periods during times of high rainfall. As a result of pumping water for irrigation, the ground-water level has receded greatly and now stands from 50 to 80 feet below the surface. None of this soil is flooded at present, and none is subject to accelerated erosion.

Chino clay loam is an extensive soil on the outer part of the alluvial fans in the northwestern part of the area, especially northwest and west of Tipton and northeast of Stoil. Scattered small areas are from 1 to 3 miles northwest of Woodville and 1 mile south of Sausalito School. This soil is associated with Chino loam, Tulare loam, Tulare clay loam, Tulare clay, Pond loam, and Pond clay loam. Where associated with the Pond soils, it includes small areas of a lighter colored soil much like the Pond soils, but these areas are too small to show separately on the soil map. The body on the northern boundary of the area 3 miles east of Waukena differs from the typical soil in that it has a clay or silty clay surface soil. The body adjoining this in the Visalia area (*9*) was mapped as Chino silty clay loam, but because of its small extent it is included with Chino clay loam in this area.

The native vegetation consists largely of grasses and associated plants common to inadequately drained land. About 50 percent of the land is cultivated, and the rest is used for pasture. Cultivation is confined largely to the areas containing only a small quantity of alkali or none. Cotton and grain, the principal crops, return good yields in places where the soil is free from salts and is sufficiently irrigated. Smaller acreages are planted to alfalfa, corn, and milo. The pasture is used largely in connection with dairying. With the exception of a few areas planted to grain and hay, all the cultivated land is irrigated.

**Chino clay loam, shallow phase (over Fresno soil material).**—The surface soil of this phase consists of dark-gray or brownish-gray clay loam that appears considerably darker when wet. It is friable, somewhat granular, micaceous, and slightly calcareous. The subsoil, to a depth ranging from 20 to 30 inches, is brownish-gray or light brownish-gray fairly compact and dense clay loam that breaks into rather rounded clods or blocks. Lime is present in the form of seams or soft nodules. In most places this layer overlies a layer of light-gray highly calcareous platy hardpan about 1 inch thick, but in some places this layer is only very slightly cemented and occurs as light brownish-gray or yellowish-gray somewhat mottled compact dense clay loam or silty clay, which contains much lime in the form of soft or semihard nodules and ranges from 10 to 20 inches in thickness. The substratum, beginning at a depth ranging from 30 to 50 inches, consists of light grayish-brown or light yellowish-gray somewhat mottled heavy loam or fine sandy loam and becomes lighter in texture with depth. It is very friable and highly calcareous in the upper part, but the lime content decreases with depth. The entire soil material is micaceous. It represents Chino

clay loam material deposited upon an older soil similar to the Fresno soils.

This soil occurs under conditions similar to those of typical Chino clay loam. Subdrainage is inadequate because the impervious hardpan layer or the compact heavy-textured layer retards the downward movement of water. Deep penetration of roots also is retarded or prohibited by this layer. About 22 percent of this soil contains a small quantity of alkali, most of which is in the lower part of the subsoil.

The largest bodies are from 2 to 5 miles north and northeast of Tipton and approximately 5 miles south of Woodville. This soil is associated with soils of the Chino, Pond, and Fresno series. Because of their small extent, a few small areas in which the surface soil is of lighter texture are included with this soil in mapping.

This soil is used in the same way as typical Chino clay loam, but in general slightly lower yields are produced.

### CHUALAR SERIES

The soils of the Chualar series have dull dark grayish-brown or dark-brown noncalcareous surface soils. The upper part of the subsoils is lighter grayish brown or reddish-brown, somewhat heavy, compact, and noncalcareous; whereas the lower part and the substratum are lighter colored, more friable, and less compact than the surface soils, and are noncalcareous.

The underlying substratum is yellow or tan-brown, mixed with rust-brown, gritty loam, which is more or less stratified in the lower lying areas. The Chualar soils occupy high well-drained alluvial terraces and old alluvial fans, with included areas occupying narrow valleys extending through the Ducor soils. These soils are developed on alluvial materials derived mainly from granitic materials washed down from soils to the east.

In virgin areas the Chualar soils are covered with an almost pure stand of grass and associated herbaceous plants.

**Chualar clay loam.**—The surface soil of Chualar clay loam, to a depth of about 10 inches, is dark-brown or dark grayish-brown coarse gritty clay loam. It is somewhat darker when moist and breaks into small clods. It is noncalcareous; neither the surface soil nor the subsoil effervesces on contact with dilute acid. This soil is friable and easy to cultivate when moist, but, like most soils in this section, it is hard when dry. The upper part of the subsoil, between depths of 10 and 50 inches, is brown slightly compact clay loam. The material in the first few inches of this layer is slightly dark when moist. It becomes more compact with depth and is rather hard to penetrate when dry. It breaks into irregular more or less vesicular aggregates from ½ to 4 inches in diameter. A trace of granitic gravel and coarse sand may be present in any part of the soil material. Between depths of 28 and 40 inches the lower part of the subsoil is brown or yellowish-brown very compact clay loam or heavy loam. It is rather hard to penetrate, and breaks into angular blocks when dry, but is penetrated by roots. It is underlain by yellowish-brown or brownish-yellow friable somewhat gritty loam or sandy loam that is not compact. Be-

low a depth of 72 inches the substratum is faintly stratified loam and sandy loam.

This soil contains a moderate quantity of organic material. It is a fertile soil, and no fertilizer is used for ordinary field crops.

The surface is nearly flat in some areas, but surface drainage is adequate for this section. The land lies favorably for irrigation, but very little water is available for irrigation on this soil. Only the steeper margins of some areas are susceptible to erosion.

Chualar clay loam occurs in small bodies, mostly around Terra Bella and Ducor, and it occupies only a small total area. Probably 90 percent of the land is under cultivation, and the rest serves as pasture. This soil is used mostly for the production of wheat and some barley. Wheat yields from 10 to 15 bushels an acre. Unfavorable air drainage on areas of this soil makes it undesirable for oranges. A few almonds, figs, and other deciduous fruits have been planted but have for the most part been abandoned, owing largely to a shortage of water for irrigation.

As mapped in this area, this soil includes several narrow areas of a darker colored soil, which have been subject to somewhat moister conditions and which occupy local swales and bottoms of intermittent streams.

**Chualar sandy clay loam.**—The surface soil of Chualar sandy clay loam, to a depth of about 12 inches, is rather dark-brown heavy gritty sandy clay loam containing some gravel and coarse sand in most places. It is rather hard to penetrate when dry and breaks into angular clods about 3 inches in diameter. The upper part of the subsoil, between depths of about 12 and 30 inches, is tan-brown gritty sandy clay loam or clay loam, with some yellowish-brown, rust-brown, and dark-brown mottlings. The material in the first few inches of this layer is somewhat darker when moist. It contains some gravel and coarse sand, mostly of granitic origin, but in places some is from basic igneous rocks. The material in this layer is rather compact when dry and breaks into angular clods. In some areas bordering the San Joaquin soils, the material in the lower few inches of this layer is very compact and is more red than the material above. The lower part of the subsoil, which reaches a depth of about 60 inches, is light-brown or brownish-tan coarse-textured loam or gritty clay loam. This includes some streaks and specks of rust brown, limonite yellow, and dark brown. This layer is more or less stratified in the lower part and in places includes layers of sandy loam, gravelly loam, and clay.

The entire soil material is noncalcareous. This soil has a fairly high content of organic matter. It has somewhat restricted surface drainage and subdrainage but is free from alkali.

This soil occupies narrow strips along drainageways from Terra Bella south to the county line. The total area is not large. Probably 60 percent of the land is under cultivation and devoted almost entirely to wheat, which produces an average acre yield of about 13 bushels, or about the same as is produced on Ducor adobe clay. Chualar clay loam supports very good pasture. The water from higher slopes provides some additional moisture, which helps the growth of grass. Most of the virgin areas are contiguous to the rolling phase of Ducor adobe clay.

**Chualar sandy clay loam, shallow phase (over San Joaquin soil material).**—This soil resembles typical Chualar sandy clay loam except that it has a reddish-brown noncalcareous hardpan, about 12 inches thick, at an average depth of 30 inches. This hardpan is similar to that under the San Joaquin soils. This soil is developed on smooth, level benches.

Probably 65 percent of the land is used for wheat and the rest for native pasture. Wheat yields average about 13 bushels an acre.

**Chualar clay.**—The surface soil of Chualar clay is dark grayish-brown clay to a depth of about 15 inches. It is hard when dry and breaks into angular clods and blocks. The upper part of the subsoil, between depths of about 15 and 34 inches, is tan-brown clay intermingled with some rust brown, yellowish brown, and dark brown. The material in the first few inches of this layer is darker when moist. It contains some coarse white sand and a trace of granitic gravel. It is rather hard to penetrate when dry and breaks into large angular fragments. The lower part of the subsoil, which reaches a depth of about 60 inches, is yellowish-brown or tan-brown clay containing streaks and specks of rust brown, dark brown, and limonite yellow. The lower part of this layer is faintly stratified in places and contains strata of gravelly loam, sandy loam, and loam.

This soil covers only a small total area. It is in low benchlike bodies along shallow swales. This is a fertile soil, but it is hard to cultivate. About 65 percent of the land is used for the production of wheat, some is in barley, and the rest is used for native pasture. Yields of wheat are about the same as the average for the area as a whole.

### DELANO SERIES

The members of the Delano series have brown or light-brown surface soils that are typically noncalcareous when tested with dilute hydrochloric acid but are basic in reaction. The soils appear darker brown or chocolate brown when wet. On drying, the surface soils are cloddy. At a depth ranging from about 12 to 20 inches the soil material becomes slightly lighter brown, slightly compacted, somewhat heavier textured, and calcareous. The lime is more or less evenly distributed. This layer rests on brown compact heavy silty clay loam or clay, which contains lime in large soft nodules and seams. When dry the material in this layer breaks into cubical blocks. At a depth ranging from 3 to 5 feet is brown or rust-brown loam or clay loam containing less lime and showing less compaction than the material in the layer above. Quartz and mica particles occur throughout the soil mass. The Delano soils occupy sloping alluvial fans that in places have a microrelief of low mounds and depressions (hog wallows). They are developed on old alluvial deposits, mainly of granitic but of somewhat mixed origin, and they have heavier textured and more compact subsoils than the Hesperia soils. On first appearance they resemble the Madera soils, but they lack the hardpan layer. The native cover is mainly grass. Drainage is fairly well developed, and the soils normally do not contain alkali in injurious quantities.

In this area the Delano soils occur at lower elevations than the Ducor and San Joaquin soils. Only Delano clay loam is mapped.

**Delano clay loam.**—The surface soil of Delano clay loam is brown or light-brown clay loam. It is typically noncalcareous but is alkaline in reaction. It is micaceous, although the parent material in this area are somewhat mixed in geologic origin. At a depth ranging from 12 to 20 inches the soil material in most places is brown calcareous clay loam, slightly or moderately compact. The lower part of the subsoil is commonly brown compact clay loam or clay, which contains lime in large nodules or seams and has a cubical structure when dry. At a depth ranging from 36 to 60 inches this material grades into rust-brown clay loam or loam, which is fairly compact but not so heavy textured, compact, or filled with lime as the material above.

Delano clay loam occupies sloping alluvial fans at a somewhat lower elevation than the San Joaquin and Ducor soils. A few low hog wallows are present but are not so well developed as in the Madera or San Joaquin soils. Owing to the lower position, water stands on the surface after heavy rains. Delano clay loam has much the same surface appearance as the Madera soils, but it lacks the hardpan of the Madera except in transitional areas along the line of contact. This soil does not contain injurious accumulations of alkali.

Delano clay loam seems to be well supplied with most of the plant nutrients, although it is somewhat low in organic matter. Owing to its association with the hardpan soils, it is used for growing grain, and when moisture is available good yields are obtained. This soil probably would give good results for a fairly wide range of crops, but it occurs west of Terra Bella and south of Vestal, where little water is available for irrigation.

### POND SERIES

The Pond soils have light brownish-gray or light-gray compact somewhat platy surface soils to an average depth of about 8 inches. The material in the topmost 2 or 3 inches is generally vesicular and, in the bare areas, very fluffy when dry. The organic-matter content is very low. Large areas support no vegetation, owing to the accumulation of alkali. In dry weather an efflorescence of lime and alkali occurs on the fissure planes and on the surface of the bare spots. Black alkali stains are common in the surface soils and in the upper subsoil layers. The upper subsoil layers in most places are light brownish gray, drab, or light olive brown, with a blocky or faint columnar structure, to a depth of about 18 inches. These soils contain many soft lime nodules from ¼ to 1 inch in diameter. When dry the material is very compact and hard to penetrate. Between depths of about 18 and 40 inches is the zone of maximum compaction, in which the material has a blocky structure and is slightly yellowish gray. This layer contains much segregated lime. The material is difficult to penetrate with digging tools and is very dense, but it is not firmly cemented and is penetrated by a few plant roots. It gradually becomes less compact with depth but is very compact to a depth of more than 60 inches.

The subsoils are relatively impervious to water and have a low water-holding capacity. The land is almost flat with a slope to the west ranging from 5 to 10 feet to the mile. Low mounds give these soils an indefinite hog-wallow relief.

Surface drainage and subdrainage are very poor. All the Pond soils, especially the finer textured types, contain injurious accumulations of alkali. Dark stains and tests with phenolphthalein indicate the common occurrence of black alkali throughout the soils.

The native vegetation consists of saltgrass with salt-tolerant and drought-resistant flowering plants, such as owlclover, and some shadscale and sagebrush on the better drained areas. The Pond soils contain too much alkali to be of value for farming. They would be difficult to reclaim, owing to the imperviousness of the subsoil, and would be of very low value when reclaimed.

The Pond soils are most extensive in the southwestern part of the area, where they are closely associated with the Fresno, Chino, and Tulare soils. They resemble the Fresno soils but do not have the cemented hardpan layers or such a distinct hog-wallow microrelief. Pond loam and Pond clay loam are recognized in this area.

**Pond loam.**—The surface soil of Pond loam is compact and, after drying, is highly vesicular to a depth of 4 inches, especially on the bare spots, and somewhat less vesicular to a depth of 8 inches. It is pale grayish brown or yellowish brown when moist and very gray when dry. In areas with a high salt content the immediate surface soil becomes puffy and nearly white during dry periods. The texture ranges within short distances from loam on the mounds to heavy loam or clay loam in the intervening flats or depressions. The upper part of the subsoil, between depths of 8 and 18 inches, is heavy compact somewhat micaceous loam that is brownish gray intermingled with dark drab, light greenish brown or olive brown, and rust brown. The structure is irregularly blocky or faintly columnar. This very compact material is difficult to penetrate with digging tools. The texture ranges from heavy loam or clay loam to sandy clay or silty clay. Occurring between depths of about 18 and 40 inches, the middle part of the subsoil is much like the material above, except that it is slightly coarser textured and more yellow. Many soft nodules of segregated lime appear in the first few inches of this layer, and a few plant roots penetrate the material. The lower part of the subsoil, between depths of 40 and 72 inches, is grayish brownish-yellow or light yellowish-gray compact loam, somewhat streaked with rust-brown, gray, and drab mottling. This material is less compact than that in the layer above and becomes less compact with depth. In places, especially near areas of the Tulare soils, layers of sand occur below a depth of 72 inches.

Pond loam has a low water-holding capacity, owing to its impervious character. It is hard to cultivate, as it bakes hard when dry and is sticky and slushy when wet. The surface is flat with low mounds, which gives it a faint hog-wallow relief. Surface drainage and underdrainage are poor, and water stands in the depressions during the infrequent winter rains. Pond loam is the most extensive soil in the area. It occurs chiefly in the western part between Earlimart and Waukena. Less than 1 percent of this soil is farmed, but more of it has been cultivated and later abandoned because of its unproductiveness. It furnishes some scant grazing in the spring after moist winters, but it is barren during the dry summer season. The cultivated areas are irrigated, but crop yields are low.

**Pond clay loam.**—The surface soil of Pond clay loam is gray platy highly vesicular clay loam to a depth of 3 inches. It is light gray when dry and pale grayish brown or yellowish brown when moist. Both the surface soil and the subsoil are highly calcareous and impregnated with alkali. Between depths of about 3 and 14 inches the soil is light grayish-brown or pale yellowish-brown compact clay loam, with a coating of gray on the structure planes, and it is decidedly gray when dry. It is vesicular and breaks into blocks having a faint horizontal breakage. The subsoil, between depths of 14 and 30 inches, is brownish-gray clay loam or silty clay, which is grayish yellow or brownish yellow when moist. It breaks into an irregular-rounded nut and cloddy structure. When dry this material is very compact and difficult to break with a crowbar, although it is not a cemented hardpan. The substratum, between depths of about 30 and 60 inches, is brownish-gray compact faintly vesicular clay loam that is grayish brown or yellowish brown when moist. This material contains many grayish-yellow hard lime concretions and much gray segregated lime in the upper part. It has a faint nut to irregular breakage, changing to a horizontal breakage in the lower part. This material passes into grayish-yellow or light brownish-gray somewhat coarser material, ranging from clay loam to sandy clay, with a few layers of sand. This soil contains considerable mica. Except in small spots, it is low in organic matter.

Pond clay loam is developed on broad flat slightly depressed poorly drained areas, and water stands on the surface after showers during moist winters. The largest bodies are south of Allensworth and southeast of Waukena. This soil is closely associated with Pond loam. The native vegetation consists of saltgrass, some alkali-resistant flowering plants, and a few shadscale bushes. The vegetation is sparse, about one-fourth of the surface consisting of white bare spots, and it is of low value for native pasture. None of the land is cultivated at present, as it contains much alkali and would be difficult to reclaim, owing to the compact subsoil and the flat surface.

### TRAVER SERIES

The surface soils of members of the Traver series are light gray when dry and become light grayish brown or brown when moist. They are calcareous and micaceous. When dry, they bake and become hard, and they have a vesicular and platy structure in the upper few inches. The upper subsoil layer is gray or light brownish gray, somewhat mottled with yellowish brown and rust brown. This layer is generally more compact than the surface soil, is highly calcareous, and has a cloddy structure. The lower subsoil layer is more friable than the layer above, is highly calcareous, and, in places, is mottled with iron stains.

The Traver soils are developed on broad gently sloping or nearly flat valley plains and old alluvial fan deposits mainly of granitic origin. Surface drainage is rather slow, and subdrainage is impaired. Excessive accumulations of salts occur in many places. The native vegetation consists mainly of saltgrass, with associated grasses and salt-tolerant plants.

The Traver soils resemble in occurrence and appearance the Fresno and Pond soils, from which they are differentiated by the absence of

the more compact or cemented subsoil layers. At the time of the earlier reconnaissance surveys they had not been identified and were included with the Fresno soils. Traver fine sandy loam is the only type mapped.

**Traver fine sandy loam.**—The surface soil of Traver fine sandy loam is gray or light brownish-gray calcareous fine sandy loam to a depth of about 4 inches. Between depths of 4 and 18 inches the soil is brownish-gray or light grayish-brown calcareous fine sandy loam that is slightly compact and bakes hard on drying. It breaks to an irregular blocky structure and contains some lime on the fissure planes. Plant roots penetrate this soil easily. This material grades into brownish-gray or grayish-yellow compact sandy loam or fine sandy loam, which extends to a depth of more than 40 inches. It becomes more yellow with depth, contains slightly more fine material than the layer above, and becomes compact and hard when dry. Plant roots tend to follow cleavage planes. Areas bordering Pond loam in many places have a very compact layer at a depth of about 40 inches. The substratum, between depths of 40 and 72 inches, is brownish-gray or pale grayish-yellow calcareous sandy loam containing rust-brown specks and splotches of gray and yellow. It is friable when moist but bakes on drying. Coarse sand and mica occur throughout this soil; and, in places, layers of sand and heavier material occur in the lower part of the subsoil. The soil contains considerable alkali, and black alkali stains are common in the surface soil.

This soil is developed on low ridges from 1 to 2 feet above the surrounding soils. The surface is nearly flat. Surface drainage is fairly good, but underdrainage is somewhat restricted.

Traver fine sandy loam is associated with soils of the Pond and Chino series. Most of it occurs in scattered bodies in the western part of the area. It covers a very large total area.

The position of this soil on low ridges is favorable for irrigation by gravity. The uncultivated areas provide some pasture of saltgrass and associated grasses and plants (pl. 3, *A*). Small areas are devoted to barley, alfalfa, grain sorghums, and truck crops, but yields are low.

A small area joins with Traver loam of the Visalia area, in which the fine sandy loam was not mapped because of its small extent.

### WAUKENA SERIES

The surface soils of members of the Waukena series are light brownish gray, vesicular and platy in the upper few inches, and alkaline in reaction, but they do not effervesce with acid under typical conditions. Grass roots fill these layers. They are underlain abruptly by layers of brownish-gray noncalcareous tough heavy-textured material that has a columnar solonetzlike structure. This grades into a light grayish-brown or pale yellowish-brown somewhat less dense lower subsoil layer, which contains much segregated lime in the form of mottlings, seams, and nodules. The material in this layer becomes more friable and shows less conspicuous segregations of lime with increase in depth.

In occurrence, parent materials, relief, and agricultural use, these soils are similar to the soils of the Traver series, from which they

are differentiated by the leached surface soils and the development of the dense solonetzlike subsoils. Waukena fine sandy loam is the only type mapped in the Pixley area.

**Waukena fine sandy loam.**—The surface soil of Waukena fine sandy loam is light brownish-gray fine sandy loam to an average depth of 8 inches. It has a pH value of 7.8 to 8.0. After drying, the surface soil is vesicular to a depth of 2 to 4 inches, and it contains many grass roots. The surface soil passes sharply into a 9-inch layer of brownish-gray very compact dense sandy clay of columnar solonetzlike structure. The columns are about 2 or 3 inches in diameter and have rounded tops coated with light gray. The interiors of the columns are speckled with rust brown, dark brown, and gray; but the surface of the columns is more gray. The columnar structure varies considerably within short distances in the soil. The subsoil, between depths of 16 and 24 inches, is grayish-brown, yellowish-brown, or brownish-gray highly calcareous rather compact sandy clay, which contains a large amount of segregated lime and many lime nodules, and breaks with a conchoidal fracture. The lower part of the subsoil is pale grayish-brown or yellowish-brown sandy clay containing streaks of gray. It is micaceous and highly calcareous but contains less segregated lime than the layer above. It is moderately friable and has a low organic-matter content.

The land is nearly level, with low mounds and depressions, and both surface drainage and underdrainage are somewhat deficient. This is not a productive soil, but the untilled areas are considered fair pasture land. Less than 5 percent of the land is cultivated. A few spots in close association with better soils are cultivated in order to preserve the regularity of the fields. Cotton is the most important crop, but yields are low.

Only a few spots, covering a small total area, occur, and these are mainly in the northwestern part of the area.

### TULARE SERIES

The surface soils of members of the Tulare series are gray or brownish gray when dry and become somewhat browner or darker when moist. The lighter textured types contain little organic matter, but the heavier textured types have a much higher organic-matter content. They are calcareous and effervesce freely with dilute acid. The surface soils and subsoils contain many white shells, shell fragments of fresh-water mollusks, small hard brown ferruginous nodules, and greenish-brown shaly concretions. The upper part of the subsoil is predominantly drab gray when dry and pale greenish brown or drab brown when moist. In structure the material in this layer ranges from platy to prismatic. The upper part of the subsoil is compact when dry but generally is not distinctly heavier than the surface soils. This layer contains some segregated lime and limonite-yellow, rust-red, and dark mottling. The lower subsoil layer below a depth of 40 inches, is about the same color as the layer above, but it is more distinctly laminated. At an average depth of about 8 feet this layer passes into lake-laid clay stratified with lighter textured materials.

The Tulare soils are developed on lake-laid materials of mixed origin, which were deposited in a lake that fluctuated greatly in depth. These soils have been alternately dry and covered with water until

recent times. Buried soils, indicated by dark layers, occur in many places.

In this area the surface is flat, with an average westward slope of less than 5 feet to the mile. Surface and subsurface drainage are impaired, especially in the heavier textured soils. Many areas of the loam, clay loam, and clay types are too level for effective distribution of irrigation water.

All the Tulare soils in this area have a relatively high content of salts, especially in the lower part of the subsoils, and these salts tend to accumulate in the surface layers. The sandy types contain the least and the heavy-textured types the heavier concentrations of salts. Reclamation of these soils would be difficult, owing to the heavy rather impervious subsoils, although not so difficult as that of the Fresno and Pond soils. Shortage of water makes reclamation of these soils impracticable and unprofitable at present, as the available water can be used more profitably on better soils.

The native vegetation consists of a thin growth of grass and alkali-tolerant flowering plants, with some shadscale and sagebrush on the better drained areas. Many bare alkali spots are on the heavier soil types.

Five types of the Tulare series occur in this area—Tulare fine sand, Tulare very fine sandy loam, Tulare loam, Tulare clay loam, and Tulare clay. These soils occur only in the western part. Tulare fine sand occurs on old beach lines, and the heavier types on progressively lower and flatter areas.

**Tulare fine sand.**—The surface soil of Tulare fine sand is light-gray calcareous fine sand to an average depth of about 24 inches but ranging from 8 to 36 inches. This material is slightly coherent, with a single-grain structure, and in places it ranges in texture from fine sandy loam to fine sand. The sandy surface soil contains a large quantity of shell fragments. This material passes abruptly into material ranging in texture from sandy clay to clay and in color from light gray to greenish brown. It is somewhat compact and breaks into small chunks and irregular fragments. It contains many shell fragments, some segregated lime, some rust-brown or greenish-brown rather soft concretions, and in places considerable mica. The lower part of the subsoil, beginning at an average depth of about 45 inches, is light-yellow or gray slightly compact silty clay or sandy clay. This material breaks with a horizontal cleavage into irregular fragments. It becomes more stratified with depth and is underlain by clay containing seams of sand.

Tulare fine sand occurs on old beaches of Tulare Lake. It has a much lighter color and lower organic-matter content than do the other Tulare soils and is not productive. Less than 3 percent of the land is cultivated. A few spots, less sandy than the average in the western part of the area, are farmed. This soil contains less alkali than the heavier textured types of the Tulare series but is lacking in fertility. Virgin areas are covered with a fair stand of grass that furnishes good pasture in the moist season.

**Tulare very fine sandy loam.**—When dry the surface soil of Tulare very fine sandy loam is gray smooth floury calcareous even-textured very fine sandy loam, to a depth of 10 or more inches, and it is grayish brown when moist. The surface soil contains many

fragments of white shells and some rust-brown hard ferruginous nodules. At a depth ranging from 10 to 20 inches the material becomes somewhat platy and in most places is lighter gray. It is underlain by light yellowish-brown or drab-brown silty clay or silty clay loam, which becomes gray and compact when dry. With depth, this material becomes heavier and cloddy to feebly columnar, and many small soft segregations of lime and hard rust-brown ferruginous concretions appear. Rust-brown stains are conspicuous in channels formerly occupied by roots. The lower part of the subsoil, between depths of about 36 and 60 inches, is light brownish-gray or light-yellow sandy clay or clay, which appears gray when dry. This layer contains a few ferruginous concretions in the upper part, but no lime segregations and no roots. It is underlain by a stratified layer of sand and clay at an average depth of about 8 feet.

Tulare very fine sandy loam is better drained than the heavier textured Tulare soils. Surface drainage is somewhat restricted but is adequate for this section. Most of this soil north of Alpaugh contains a slight accumulation and other areas a moderate accumulation of alkali. Most of this soil, which covers a large total area, is in one large body near Alpaugh.

Probably 70 percent of this soil is under cultivation. About 85 percent of the area that is slightly affected with alkali is cultivated, and about half of the moderately affected area is being farmed. Many of the areas strongly affected with alkali have been farmed but now are abandoned. The main crops are cotton, alfalfa, wheat, barley, and some grain sorghum, all grown under irrigation. Some cottonfields yield more than a bale an acre, and alfalfa yields from 4 to 6 tons. Much of the wheat and barley is cut for hay, yielding about 2 tons an acre; or, when cut for grain, it yields from 20 to 30 bushels.

**Tulare loam.**—The surface soil of Tulare loam, to an average depth of about 9 inches, is gray when dry and pale grayish brown or yellowish brown when moist. The soil has a high content of fine sand but is plastic when moist. In most areas this soil has an irregular nut or cloddy structure. The upper part of the subsoil, which reaches a depth of about 28 inches, is greenish-drab or brownish-drab heavy clay loam or silty clay. The material in the first few inches of this layer is faintly columnar, and that in the last few inches has a more blocky structure. Some sand has washed into the fissure planes, giving the material a somewhat variable structure. Plant roots follow the fissure planes, and in places a trace of segregated lime occurs. The lower part of the subsoil, which reaches a depth of about 48 inches, is yellowish-gray or pale greenish-gray clay loam or silty clay. This material generally has a blocky or nut structure, and the material in the last few inches has a platy structure in places. This material passes into a stratified layer of sand and clay, which extends to a depth of 80 or more inches. The depth to the stratified material ranges from 25 to 72 inches but averages about 48 inches. Southwest of Allensworth this soil includes some spots having a surface layer, about 5 inches thick, which is slightly dark brown when moist.

Drainage is deficient, as the surface is nearly flat with a slope toward the west of less than 5 feet to the mile. The soil in most areas contains a moderate quantity of alkali.

Tulare loam occupies fairly large bodies in the southwestern part of the area. Much of this soil is transitional between Tulare clay and Tulare fine sand or Tulare very fine sandy loam. Less than 5 percent of this soil is cultivated at present. The tilled land is used mostly for grain and cotton, but yields are low. Probably 40 percent has been cultivated and abandoned. The virgin areas are covered with a thin growth of grass, alkali-resistant plants, and some shadscale. This soil provides fair pasture in the spring after moist winters, but the pasture is very scanty during the dry summer.

**Tulare clay loam.**—The surface soil of Tulare clay loam, to an average depth of about 10 inches, is rather heavy clay loam, which is gray when dry and very light grayish brown when moist. The soil clings to the grass roots and has a somewhat granular structure. In places the upper 2 inches are somewhat vesicular. A large quantity of white fragments of fresh-water mussel shells and many rust-brown and greenish-brown concretions ½ to 1½ inches long occur in this layer. The soil is compact and hard to penetrate when dry. Both the surface soil and the subsoil are definitely calcareous. The upper part of the subsoil, between depths of about 10 and 30 inches, is olive-gray clay loam or clay, which contains many white splotches of segregated lime, many rust-red, rust-brown, and greenish-brown hard concretions ½ to 1 inch long, and numerous fragments of fresh-water mussel shells. It breaks to an irregular blocky structure, with some streaks of lime and dark material on the fissure planes. This material is compact when dry but is fairly easy to penetrate when moist. The lower part of the subsoil, between depths of 30 and 50 or more inches, is much like the material above, except that it contains little segregated lime and has a more laminated horizontal structure. It has a vitreous appearance on a cut surface and on fissure planes. It becomes more stratified with depth. It consists of pale-gray or pale grayish-brown stratified layers of sand and clay containing streaks of drab, rust-brown, and dark-brown material, many ferruginous pellets, and many hard to soft concretions. Areas of this soil bordering areas of the Pond soils are more compact in the upper part of the subsoil than elsewhere.

This soil contains a large quantity of alkali, especially in the lower part of the subsoil; and for this reason it is not adapted to deep-rooted crops. The salts now appear to be accumulating in the surface soil. Thirty years ago, or not long after Tulare Lake had retreated, the surface soil was considered free from alkali, but now bare alkali spots are numerous.

The surface is nearly flat, with a slope to the west of less than 5 feet to the mile. Drainage is deficient, and water stands on the lower areas after the winter rains.

Tulare clay loam covers a large total area, chiefly northwest and east of Alpaugh, near Turnbull, and northeast of Angiola. Probably 10 percent of this soil is now being cultivated, but about 40 percent has been cultivated and abandoned, owing to the concentration of alkali salts and a shortage of water for irrigation. All crops grown in this soil are irrigated. The largest cultivated area is along the county line northwest of Alpaugh. Cotton is grown on about 40 percent of the cultivated area and yields an average of 1 bale an acre. Wheat, barley, and some alfalfa are grown on the rest of the

land, with wheat yielding an average of about 20 bushels an acre and barley 25 bushels. Much of the grain is cut for hay. The uncultivated areas are covered with a thin growth of grass and alkali-resistant plants. The pasture is fairly good in the spring after moist winters, but after dry winters it is very scanty.

**Tulare clay.**—The surface soil of Tulare clay, to an average depth of about 12 inches, is drab-gray clay when dry and becomes somewhat more brown when moist. The structure is definitely platy when moist, but when dry the upper 3-inch layer becomes highly vesicular. The upper part of the subsoil, which reaches a depth of about 28 inches, consists of heavy compact clay. It is olive gray when dry and light greenish brown or drab brown when moist. This material is tough, waxy, and hard to penetrate. It breaks into angular chunks and blocks with horizontal stratification seams. The soil is glossy on a cut surface and on the fissure planes. It contains a few specks of segregated lime, some rust-brown concretions, and many fragments of fresh-water mussel shells. The lower part of the subsoil consists of heavy clay that is light gray or olive gray when dry and greenish brown or dull brown when moist. This material contains some segregated lime, especially in the upper part, with many rust-brown iron stains and some dark stains from infiltrated organic matter. It is less compact than the material in the horizon above, and it becomes stratified with depth. At a depth ranging from 2 to 9 feet it passes into a stratified layer of gray or grayish-yellow fine sand and clay. Some areas of this soil have a surface layer, about 3 inches thick, which is slightly dark grayish brown when moist but becomes gray when dry. Most of these areas are between Allensworth and the Kings-Tulare County line in the southwestern corner of the area.

Tulare clay contains a moderate to large quantity of alkali, with a heavy concentration of the salts in the lower part of the subsoil. This soil would be difficult to reclaim from alkali because of its impervious subsoil and poor surface drainage. It is developed in shallow basinlike areas where water stands on the surface during moist winters.

Less than 2 percent of Tulare clay is cultivated. Most of the cultivated area is in one body northwest of Alpaugh. It is devoted to grain and some cotton under irrigation, but it is hard to cultivate, owing to its heavy texture. Cotton yields about 1 bale an acre and wheat about 20 bushels. The total area is fairly large.

### HACIENDA SERIES

The surface soils of members of the Hacienda series are gray or light gray, are generally calcareous, and rest abruptly, at a depth of only a few inches, on a dense heavier textured subsoil of prismatic or columnar solonetzlike structure. This material is mottled with lime segregations. It becomes somewhat less dense in the lower part and grades into parent lake-laid sediments.

The Hacienda soils are related to and closely associated with the Tulare soils, from which they are differentiated by the dense solonetzlike subsoil. They are not extensive nor important in this area. Surface drainage is poorly developed, and subdrainage is effectively arrested by the dense subsoil. The native vegetation is dominated by

saltgrass and other grasses and salt-tolerant weeds and shrubs. The soils are of little value except for scant pasture. Hacienda fine sandy loam is the only type mapped in this area.

**Hacienda fine sandy loam.**—The surface soil of Hacienda fine sandy loam is friable fine sandy loam, which is gray or light gray when dry and darker brownish gray or grayish-brown when moist. It is calcareous and rests abruptly, at depth of only 2 to 4 inches, on a greenish-drab tough dense sandy clay subsoil of prismatic to columnar solonetzlike structure. The tops of the prisms are flat or slightly rounded and are faintly coated on the tops and sides with gray. They are about 4 inches in diameter and 4 or 5 inches long. In the lower part of this layer the prisms are less strongly developed and the material is mottled with lime segregations and is less dense. This material passes into olive-gray clay or sandy clay containing fragments of mussel shells, specks of segregated lime, and rust-brown mottlings.

The land is flat, so that surface drainage is poorly developed. Subdrainage also is much retarded. The water table fluctuates, and overflows occur during wet periods where the land is not protected by levees. Both saline and alkali salts are present in most areas. The soil supports a vegetation of saltgrass and associated grasses and salt-tolerant annuals and low-growing shrubby plants. Grass roots permeate the thin surface soil, but they follow the cracks and fissures in the subsoil material.

Hacienda fine sandy loam occupies only a small area in the extreme southwestern part of the survey. It has little agricultural value except for scanty grazing during a brief period. In some of the area occupied by this soil, variations transitional into the Tulare soils are included, in which the dense prismatic or columnar subsoil is imperfectly developed.

### PORTERVILLE SERIES

The surface soils of members of the Porterville series are chocolate brown or dark reddish brown when dry and dark chocolate brown when wet. Normally they have a heavy texture and develop an adobe structure. The adobe blocks are broken by secondary cracks to small angular fragments and clods, causing an unstable condition to a depth ranging from 3 to 6 inches. This condition is locally known as "dry bog." Under favorable conditions of moisture and tillage the soils are very friable, and the cracks afford good channels for the penetration of water and roots. When wet, the heavy texture, together with a high percentage of colloidal material, causes these soils to be very sticky; and when puddled they form dense masses that dry to hard solid blocks. Cultivation is almost impossible under such conditions. They have a moderate to low organic-matter content. The soils are neutral or basic in reaction. The thickness of the surface soils ranges from 10 to 20 inches. The subsoils are chocolate brown or dark reddish brown, are slightly heavier in texture than the surface soils, and contain a large quantity of colloidal clay. In most places they have a prismatic or blocky structure and the fragments become hard when dry. The subsoils contain seams of both disseminated and segregated lime. The content of lime increases with depth, and the soil aggregates become

softer and easier to break. Roots and water penetrate into this layer, mainly along the cracks that occur when the soils become dry. The depth of the subsoils ranges from 10 to 40 or more inches.

The substratum is generally redder and denser than the subsoils. It is reddish brown; has a high lime content, which makes the color variable; and has an angular cloddy structure. Both disseminated and segregated lime are present in seams and hard nodules. Owing to the very heavy texture and the high colloidal content, roots and water do not penetrate this layer very easily. Some mottling occurs in the lower part of the subsoils and upper part of the substratum. The substratum is fairly deep on some of the lower slopes, but in places on higher ground it rests on bedrock at a depth of less than 6 feet.

The soils of the Porterville series are developed on transported material derived primarily from basic igneous rocks. They occupy smooth gently to rather steeply sloping alluvial fans and foot slopes, but, because of their heavy texture and adobe structure, very little erosion occurs. Surface run-off is good, but subdrainage is only fair. The higher slopes are stony, and basic rocks are throughout the whole soil mass. In this area the Porterville soils are associated with the Ducor soils, which are very similar in profile development but are darker and are developed on mixed granitic and basic igneous material. They occupy slopes below the Lassen soils of the foothills. A fairly large total area is mapped, consisting of Porterville adobe clay and Porterville stony adobe clay. Most of these soils occur north, east, and southeast of Porterville.

**Porterville adobe clay.**—Porterville adobe clay occupies sloping alluvial and colluvial foot slopes of basic igneous hills from which the parent material has been derived. The surface soil, to a depth ranging from 12 to 24 inches is chocolate-brown or dark reddish-brown noncalcareous adobe clay. When wet the soil is darker and is very sticky and plastic, and when dry it cracks to a blocky adobe structure, the units of which crack further in both vertical and horizontal directions and develop a small-cloddy and angular-fragmental structure to which is commonly given the term "dry bog." The subsoil, which extends to a depth ranging from 24 to 40 inches, consists of dark chocolate-brown calcareous clay and contains lime in disseminated form and also segregated in seams. This material has a prismatic or blocky structure when dry, the units being very firm and hard. The clay substratum is lighter and more variable in color than the subsoil, being reddish brown or dark reddish brown. It is highly calcareous, with the lime in seams and in disseminated form. The structure is angular cloddy, and the units break down rather easily, owing to the high concentration of lime.

Porterville adobe clay occurs on moderately steep to gentle slopes, which afford good surface drainage. Although the texture of this soil is very fine and heavy, surface penetration of moisture is fairly good because of the adobe structure and the fine structure of the adobe units. Subsoil drainage is fairly good. Many small basic igneous rocks, mostly rounded and somewhat water-worn, occur throughout the soil mass; but these rocks are not large enough or sufficiently numerous to hinder cultivation. Practically all of this soil

is under cultivation. The lower lying areas are used for dry farming and are planted mainly to wheat and barley; but, on sloping terrain where the good air drainage affords protection from frosts, citrus fruits, chiefly navel and Valencia oranges and a few grapefruit, are important crops. A few olives and almonds are grown in the district north and slightly east of Porterville. Although this soil is not especially adapted to trees because of its heavy texture, it occurs in localities where climatic conditions are more or less ideal for the growing of citrus fruits.

This soil occupies a fairly large total area. The largest bodies are north and east of Porterville and southeast of Porterville just east of Deer Creek Colony. The body immediately east of Porterville and the one north of Porterville, which have a combined area of approximately 8 square miles, are used for the production of citrus and other irrigated fruits, and most of the rest of the land is used for dry farming.

As mapped in this survey, this soil includes a small body of about 60 acres in which a cemented hardpan has developed. This body conforms to and joins with a body of Seville adobe clay of the Visalia area. Owing to its small extent, it is included with the Porterville soils in the Pixley area.

**Porterville stony adobe clay.**—Porterville stony adobe clay is similar in color and profile development to Porterville adobe clay. It differs in having a slightly higher, more sloping relief and many more of the larger basic igneous rocks throughout the soil mass and scattered over the surface. These rocks are large enough and sufficiently numerous to make cultivation difficult. Surface run-off is good. Surface penetration of water and subsoil drainage are fair. Where air drainage and climatic conditions are favorable, some citrus fruits are grown; but the greater part of the soil is used for pasture.

Porterville adobe clay and Porterville stony adobe clay are associated with Lassen clay and Lassen stony adobe clay, which are dark-brown or chocolate-brown soils developed in place on basic igneous rocks. These soils are also associated with Ducor clay, which is very similar to the Porterville soils but has a parent material of mixed basic igneous and granitic origin.

### HOVEY SERIES

The surface soils of members of the Hovey series are dark gray when dry and black when wet, and they have a heavy clay texture. They have a typical adobe structure, in which large hard blocks, from 12 to 15 inches in diameter, are developed. The topmost 4- to 8-inch layer, in which the maximum quantity of grass roots is present, breaks further to a coarse-granular or angular-fragmental structure. The surface soils are basic in reaction, in some places being slightly calcareous. This layer generally extends to a depth ranging from 12 to 18 inches. The upper part of the subsoils is dark-gray calcareous clay that dries into fairly hard blocks. Lime is present, generally segregated in large soft nodules. The lower part of the subsoils is lighter colored, higher in lime, and somewhat lighter textured than the upper part and lacks the adobe structure of the surface soils.

The soils of the Hovey series are developed on old transported materials derived from basic igneous rocks. They occupy flat areas

at the foot of alluvial slopes most of which are occupied by Porterville adobe clay. Surface run-off is very slow, so that water stands on the surface after heavy rains. These soils have a grass cover. They do not contain alkali salts. The Hovey soils are derived from the same parent material as the Porterville soils, but they have developed under poorer drainage conditions with more luxuriant grass growth, so that the soils are darker colored. These soils were included with Montezuma clay adobe in the earlier reconnaissance survey. They differ from the Montezuma soils in character of parent materials and in minor details of profile development. Hovey adobe clay is the only type mapped in this area.

**Hovey adobe clay.**—Hovey adobe clay, to a depth of 6 or 8 inches, is dark-gray clay that cracks into large adobe blocks on drying and has a fairly high organic-matter content. The surface soil becomes black when wet. Under favorable conditions of moisture and cultivation, it breaks down very readily to a granular tilth. The upper part of the subsoil is lighter gray than the surface soil, owing to the high content of lime segregated in large nodules and seams. The lower part is lighter colored and, in some places, lighter textured than the upper part and is high in lime.

Hovey adobe clay occupies flat areas at the foot of alluvial slopes. Surface run-off is slow, so that water stands on the surface after rains. As it is heavy textured, this soil is difficult to manage under irrigation, and it has been used only for range pasture, grain, and grain hay. It rates fairly high for such crops, as it holds a large quantity of moisture and has a fertile surface soil. Its value for grain crops is limited by the low rainfall. Its low, flat position restricts its use for citrus fruits, owing to poor air drainage and danger of frost. This soil probably also contains too much lime for the growth of citrus trees.

### DUCOR SERIES

The soils of the Ducor series have dark-brown surface soils about 10 to 15 inches thick and brown or reddish-brown upper subsoil layers. The lower subsoil layers, between depths of 20 and 48 inches, are reddish-brown or brown clay containing conspicuous white splotches and specks of segregated lime. The subsoils everywhere are distinctly calcareous, and the surface soils are calcareous in many places, especially in citrus orchards where deep cultivation has turned up calcareous material. In virgin areas, however, the surface soils generally do not effervesce with acid. The substratum consists of reddish-brown calcareous clay mixed with gray weathered angular granite particles. This granitic material shows little stratification, is not water-worn, and has been transported a very short distance from the parent rock. The average depth to the parent material is between 4 and 5 feet, but it ranges from 3 feet on the eastern border of these soils to more than 6 feet in the more level areas to the west.

The Ducor soils are very uniform in the level and the steeper areas. They have strongly developed profiles. They were formed under the climate of this section without the influence of high ground water or concentration of alkali. These soils have a faint prismatic structure in the A horizons and a concentration of calcium carbonate similar to the Chernozem soils in the eastern border of the Great Plains.

The relief ranges from gently undulating on the slightly eroded alluvial fans in the western part of the area to rolling or hilly in the eastern part toward the foothills. Areas too steep for profitable farming are differentiated on the soil map as rolling phases. In the virgin state the Ducor soils are covered with an almost pure stand of grasses, alfileria, and associated herbaceous plants.

In this area the Ducor soils are closely related to the Porterville soils. They are closely associated with the noncalcareous Chualar soils developed in depressions extending through the Ducor soils and with the San Joaquin hardpan soils that extend in strips parallel to the drainageways through the Ducor soils. They are bordered on the east mainly by the Vista soils and on the west by the Delano, San Joaquin, and Exeter soils. The Ducor soils are highly esteemed as farming soils in this section, and most of the smooth areas are cultivated. Oranges are grown where water is available for irrigation, and wheat elsewhere.

Ducor clay, Ducor clay loam, with a rolling phase, and Ducor adobe clay, with a rolling phase, occur in this area.

**Ducor clay loam.**—The surface soil of Ducor clay loam is dark grayish-brown heavy clay loam to a depth of about 10 inches. It contains some fine angular granitic gravel and soft-gray granitic coarse sand, giving it a gritty texture. The structure is faintly prismatic and breaks down to angular nut or somewhat granular structure. The surface soil is neutral or faintly calcareous. The upper part of the subsoil, which extends to a depth of about 20 inches, is brown or reddish-brown gritty clay or heavy clay loam. It breaks into irregular blocks and angular chunks and is more or less sprinkled with white segregated lime. The content of lime increases with depth. Some granitic gravel and soft-gray coarse sand occur throughout the soil mass. The lower part of the subsoil, between depths of about 20 and 40 inches, is reddish-brown or brown calcareous clay splotched with conspicuous white segregated lime. It is rather hard to penetrate with a shovel when dry, and in many places it contains a rather compact layer about 6 inches thick just above the substratum. Roots go down to the upper part of this layer. The lower part of the subsoil and underlying parent substratum are almost identical with the corresponding layers of Ducor adobe clay. The substratum is mixed reddish-brown, brown, rust-brown, rust-yellow, and light-gray calcareous gravelly clay.

This soil occupies somewhat eroded gently rolling alluvial fans having a westerly slope. The relief is more rolling than that of Ducor adobe clay. This soil has a high content of organic material and is very fertile but is hard to cultivate.

About 70 percent of the land is devoted to wheat, with yields averaging about 13 bushels an acre. Very little of this soil is used for oranges, because the relief is not favorable for irrigation.

**Ducor clay loam, rolling phase.**—Ducor clay loam, rolling phase, is similar to typical Ducor clay loam except that the relief is more rolling and the soil is more variable. It ranges from stiff adobe clay at the foot of the slopes to gritty clay on the upper parts of the slopes. Practically none of the soil of this phase, which covers a rather small total area, is cultivated. It supports a good growth of grass and is highly valued for grazing.

**Ducor adobe clay.**—The surface soil of Ducor adobe clay is dark dull-brown or dark grayish-brown clay to a depth of about 15 inches. It is sticky when wet but friable when dry. It has a faint prismatic structure in virgin areas and breaks to a rather granular or faint nut structure. The surface cracks into hexagonal blocks when dry. When very dry, the soil in many cultivated areas breaks down into a granular fragmental incoherent mulch, locally known as dry bog. A few pieces of granitic gravel are scattered over the surface. The surface soil is neutral or slightly calcareous and effervesces with dilute acid in citrus orchards that have been subsoiled or cultivated deeply. The organic-matter content is exceptionally high for a soil in this section. The surface soil is grayer when dry, and in virgin areas during the dry season it is distinctly gray to a depth of 1 or 2 inches.

The upper part of the subsoil between depths of about 16 and 24 inches is brown or reddish-brown heavy clay speckled and slightly streaked with white lime segregations, which give it a faint gray cast. This layer contains a few hard lime nodules about one-half inch in diameter, a trace of granitic gravel and coarse white quartz particles, and many small roots. The material breaks into angular irregular chunks 1 or 2 inches in diameter. The material in this layer is highly calcareous and effervesces strongly with acid.

The lower part of the subsoil, between depths of about 24 and 50 inches, is brownish-red or rich-brown heavy clay conspicuously splotched and streaked with lime, locally called "lime blossoms." The lime gives the material a gray appearance from a distance. The lime becomes more conspicuous with depth. The reddish-brown and brown colors are faintly intermingled in many places, giving the material a finely variegated appearance on close inspection. This layer is somewhat compact when dry but is not especially hard to penetrate for such a heavy-textured soil. It breaks into small angular aggregates. In many places a rather compact 6-inch layer occurs near the substratum. This material contains many hard, roughly rounded, and elongated lime nodules one-half inch in diameter and a trace of granitic gravel and angular white quartz particles. The lower part of the subsoil passes sharply into the substratum or parent material, which is reddish brown, more or less intermingled with tan brown, rust brown, and rust yellow, and contains some gray lime segregation, much broken down granitic material, and some white angular coarse quartz sand. The material ranges in texture from gritty clay to gravelly loam. The substratum lies from 3 to 6 feet below the surface.

Ducor adobe clay is well drained and free from alkali. It is a very fertile soil, rich in plant nutrients, and produces large crops when there is sufficient moisture. Owing to its heavy character, it is hard to cultivate and must be cultivated at its optimum moisture content. It dries and cracks in dry weather. This soil is a little too heavy textured for plants to resist drought well. Most of this soil is developed on slightly eroded, gently undulating alluvial fans and terraces having a gentle slope to the west, but the land becomes more rolling to the east where it joins rolling or hilly areas occupied by the rolling phase of the soil. Very little of this soil has sufficient

slope to interfere with cultivation. The relief is essentially constructional.

This soil is very resistant to erosion and is nearly as deep on the slopes as on the more level areas. The more rolling areas, however, should be plowed along the contour lines instead of up and down the slope as at present. Surface run-off is slight, and most of the rainfall is absorbed by the soil.

In this area, Ducor adobe clay occurs only within a belt, covering about 43 square miles, between the foothills from Porterville south to the border of the area. It is derived predominantly from granitic material transported a very short distance from the foothills and mountains to the east. The parent material is not water-worn and is practically unassorted and unstratified. The native vegetation consists of a fairly heavy nearly pure stand of grasses and herbaceous plants. Virgin areas provide good pasture, considering the low rainfall of this section. Most of this soil, except in areas surrounded by the more rolling land, is cultivated. The largest acreage, probably 70 percent, is devoted to wheat as a dry-farmed crop (pl. 3, *B*) and is left in fallow about every second or third year. Yields of wheat range from 25 bushels an acre in the moist years to very little in the driest years. The average is probably about 13 bushels an acre. At present very little water is available for irrigation on this soil from wells or by gravity south of Terra Bella. The greater part of the area between Terra Bella and Porterville is irrigated, mostly by pumping from wells. Here the smoother areas of this soil are devoted largely to citrus fruits, mostly navel oranges, some olives and pomegranates, and to truck crops, especially tomatoes. According to the growers, the yield of oranges is about the same as the average for this section. Tomatoes of fine quality for table use are produced on this heavy soil. Almonds, peaches, and other fruits apparently have not been very successful, as most of the orchards have been abandoned. Water on this soil costs about $10 an acre-foot, or $25 to $30 an acre for the season, and the cost of the water is increasing with the lowering of water in the wells. This soil is located just below the foothills, where the air drainage is good and the susceptibility to frost is relatively low for this locality, which, combined, make it desirable for citrus fruits (pl. 3, *B*).

**Ducor adobe clay, rolling phase.**—The rolling phase of Ducor adobe clay has practically the same soil profile as the typical soil, except that it is more variable and more shallow. The depth to the substratum is about 40 inches, compared with 50 inches or more for the typical soil. Generally this soil is heavy plastic adobe clay at the foot of the slopes and gritty clay on the upper part of the slopes. It occurs mainly in two large bodies near Quincy School in the southeastern part of the area. The land is rolling or hilly with slopes ranging from about 10 to 35 percent.

Practically none of this soil is cultivated, except a few spots in order to preserve the regularity of the wheatfields on adjacent soils. Dry farming would not be profitable, and the relief makes the land unsuitable for irrigation even if water were available. The steep slopes are a serious obstacle to the heavy farming machinery used in the section. This soil is not especially susceptible to erosion, but where

farmed, it should be protected by cultivating along the contour. It is covered with a heavy sod of native grasses, which makes it a valuable grazing soil.

**Ducor clay.**—Ducor clay is a transitional soil between the Ducor and the Porterville soils. In some areas it resembles Ducor adobe clay; in others it more closely resembles Porterville adobe clay. The surface soil, to a depth of about 12 inches, is dark grayish-brown clay or chocolate-brown adobe clay. It is sticky and plastic when wet and breaks into large blocks and clods and into small angular fragments when dry. The surface soil is very faintly calcareous and effervesces slightly with acid in many virgin areas and in all fields that have undergone deep tillage. The upper part of the subsoil, which reaches a depth of about 22 inches, is tan-brown or chocolate-brown heavy clay or adobe clay with some white splotches of lime, which give it a faint-gray cast. It contains some soft lime nodules. This layer is slightly darker when moist. The lower part of the subsoil is tan-brown, chocolate-brown, or chocolate-red heavy clay conspicuously splotched with white lime incrustations. These "lime blossoms" increase with depth. In areas that border Porterville adobe clay the material becomes more red with depth. The substratum, which begins at a depth of 50 inches, consists of more or less mixed secondary granitic and basic igneous disintegrated rock fragments, with rust-brown, chocolate-brown, tan-brown, and lime-gray gritty clay or clay loam interstitial material.

One small body of this soil covering 60 acres in secs. 4 and 5, T. 22 S., R. 28 E., has a calcareous hardpan 6 inches thick at a depth ranging from 2 to 4 feet.

Ducor clay is well drained and free from alkali, and its organic-matter content is fairly high. It is a very fertile soil, high in plant nutrients, but rather difficult to cultivate, owing to its heavy, plastic character. Orange growers say this soil requires practically no amendment except barnyard manure. It is developed on gently undulating very slightly eroded alluvial fans and terraces, but it is not especially susceptible to erosion. The relief is favorable for irrigation in most areas where water is available. This soil occurs within a belt lying below the foothills east of Porterville.

Probably 75 percent of this land is cultivated, and probably 40 percent of the cultivated area is devoted to grain and grain hay. The yield of wheat is lower than on Ducor adobe clay. The rest of the land is used for the production of oranges, truck crops, olives, and pomegranates. All this land is in locations with good air drainage, where the danger of frost is relatively low. Orange trees do not look quite so thrifty on this soil as on Ducor adobe clay, although growers say the yields compare favorably with the average yields in this section. This heavy soil produces a very fine grade of tomatoes for table use. Virgin areas are covered with a good growth of native grass.

### EXETER SERIES

The surface soils of members of the Exeter series are light brown or medium brown, are fairly friable, and have a pH value ranging from 7.0 to 7.5, according to field tests. The surface of many dry cultivated fields has a slight red cast. The organic-matter content

is relatively low. At a depth ranging from 8 to 16 inches the material grades into a layer of yellowish-brown or light-brown material that in places has a slight red cast. This material is very friable, shows little or no definite particle breakage, and is only slightly heavier in texture than the surface soil. At a depth ranging from 20 to 50 inches this layer rests on a reddish-brown or light-brown hardpan generally having brownish-red coatings. It consists of sandy granitic material, firmly cemented, largely by sesquioxides. It is hard, dense, impervious to water, and impermeable to plant roots, which flatten out on the surface of the hardpan. The topmost 2 to 5 inches of the hardpan in most places is noncalcareous, although in places it is slightly calcareous. The lower part of the hardpan layer is less red and more brown or yellow and is less hard and dense than the upper part. It contains more or less lime in the form of seams and soft nodules. In some places the hardpan is somewhat softer than typical and, in places, has a very thin calcareous layer immediately above it. The hardpan layer ranges from 9 to 30 inches in thickness. The substratum beneath it consists of light yellowish-brown or brownish-yellow sandy loam that is somewhat compact in place, massive or single grain in structure, and slightly calcareous. It becomes less compact, looser, and less calcareous with depth.

In the earlier reconnaissance surveys the Exeter soils were included with the Madera soils, which they resemble somewhat.

The Exeter soils are developed on unconsolidated material deposited by the larger streams emerging from the mountains to the east of the area. They are derived largely from granitic material and contain some mica. They generally occur on broad gently sloping old alluvial fans or low terraces that are now considerably above the level of the alluvial flood plains. A few small areas occur in the alluvial valley of the White River on low terraces just a few feet above the flood plain. The surface is slightly undulating in a few areas along the White River southeast of Ducor. Except where leveled, the surface generally consists of more or less numerous low, broad, rounded mounds about 1 foot or more in height with intervening enclosed depressions or hog wallows. These hog wallows are not so large or so numerous as in the San Joaquin soils. Although the general slope is sufficient for good surface drainage, water collects and remains in the depressions during much of the rainy season. The presence of the hardpan layer restricts subdrainage to a great extent. No alkali is present in any of the soils. The native vegetation consists largely of grasses, with a few scattered oaks.

The Exeter soils are associated with soils of the Madera, San Joaquin, Delano, Ducor, and Greenfield series. Most areas of them lie above the Madera soils and below the San Joaquin soils. They differ from the Madera soils in being noncalcareous in the subsoil and in having a noncalcareous upper hardpan. They differ from the San Joaquin soils in being brown instead of reddish brown, having only slightly compact and heavier subsoils, and having a hardpan that is less hard, less dense, and less red. None of the Delano, Ducor, or Greenfield soils has a hardpan layer. Exeter sandy loam, Exeter loam, and Exeter clay loam occur in this area.

**Exeter sandy loam.**—The surface soil of Exeter sandy loam consists of light-brown, in many places slightly yellowish brown, sandy

loam. In some places the material is slightly heavier in texture than sandy loam, but in many other places it contains much coarse grit or sand. At a depth ranging from 10 to 16 inches the surface soil grades into yellowish-brown, in places slightly reddish brown, heavy sandy loam or coarse gritty loam containing much coarse sand. This material is friable and only slightly compact. At a depth ranging from 24 to 60 inches, but averaging between 30 and 36 inches, this overlies a reddish-brown, light-brown, or yellowish-brown indurated hardpan generally containing much brownish-red coating. The hardpan consists of sandy material cemented largely by sesquioxides. It is very dense and moderately hard but can be broken easily with a crowbar. The lower part of the hardpan is somewhat less hard, less firmly cemented, and less red than the upper part. The hardpan ranges from 10 to 20 inches in thickness, and the degree of hardness also is rather variable. This layer overlies the substratum, which consists of light yellowish-brown or brownish-yellow friable sandy loam containing much coarse sand. The entire soil material contains some mica. It has been formed from old water-laid deposits derived chiefly from granitic sources.

The surface soil is friable and is easy to till, although, if cultivated under unfavorable conditions, it may clod or puddle and bake somewhat on drying. Above the hardpan the soil is very permeable to roots and water and holds a relatively large quantity of available water. As the hardpan layer is impenetrable to roots, the deeper roots go down to the hardpan and then spread out laterally on its surface. Before trees or vines are planted in areas where the hardpan is near the surface, the hardpan layer is generally blasted and broken so as to allow deeper penetration of roots and better moisture and drainage conditions.

No alkali is present in any of the areas. The soil above the hardpan and the topmost few inches of this layer have a pH value ranging from 7.0 to 7.8, the topmost part of the hardpan being slightly more alkaline than the surface soil. The lower part of the hardpan is calcareous and contains lime in the form of seams and soft nodules. In most places the substratum contains small quantities of lime. Comparatively little organic matter and nitrogen are present, although these are higher than in the San Joaquin soils. Other plant nutrients are present in sufficient quantities for ordinary crop production.

Exeter sandy loam occurs extensively on broad gently sloping old alluvial fans and rather low terraces. A few small bodies occupy comparatively long narrow sandy ridges or narrow old intermittent stream channels and drainageways and have a gently undulating relief. The bodies show little or no erosion, and practically all of the land is adapted to extensive tillage operations. Unless leveled, the surface in general is characterized by scattered broad, low, rounded mounds and intervening depressions, commonly known as hog wallows. The mounds are from 6 inches to 1½ feet in height and from 10 to 20 feet in width.

The material on the tops of the mounds is more sandy, somewhat lighter colored, more droughty, and deeper over the hardpan layer than that in the depressions, which is somewhat heavier textured, somewhat darker, and generally shallow over the hardpan layer. More organic matter has accumulated in the depressions than on the tops

of the mounds. The hog wallows are much less pronounced and less numerous than on Exeter loam or on the Madera and San Joaquin soils. Some leveling is necessary for irrigation, but it is much less of a problem than on the other soils.

In most places the slope is sufficient for good surface drainage, but where hog wallows are present water collects and stands in the depressions for considerable periods during the rainy season. Subdrainage is greatly restricted by the presence of the hardpan layer. During the rainy season this layer retards the downward movement of water, causing the soil above the hardpan to be water-soaked, especially in the depressions. During the dry season the hardpan prevents the upward percolation of water, thereby causing the soil to be more droughty.

By far the largest body of Exeter sandy loam lies between Ducor and Earlimart; small scattered bodies are near Richgrove, northwest of Vestal, about 3 miles northwest of Quincy School, 3 miles south of Ultra, 1½ miles southwest of Sausalito School, and 4 or 5 miles northwest of Terra Bella. This soil is associated with Exeter loam, Greenfield sandy loam, Hesperia loam, Madera loam, and San Joaquin loam.

Included with mapped areas of this soil are small scattered bodies in which a thin calcareous layer lies just above the hardpan. This inclusion is intermediate between Exeter sandy loam and Madera sandy loam. Small areas of Greenfield sandy loam that are too small to separate on the map also are included.

The native vegetation of Exeter sandy loam consisted largely of grasses, with a few scattered oaks. About 95 percent of the land is cropped, and the rest is used for pasture. Wheat is grown on about 50 percent of the cropland, and none of the wheatland is irrigated. The general practice is to grow wheat every other year, the land being summer-fallowed during the intervening years. Fairly good yields of wheat are produced. They range from 5 to 25 bushels an acre and average about 15 bushels. This is one of the best soils for dry-farmed grain, and a fair yield is nearly always assured. Other crops grown include cotton, grapes, and deciduous fruits. The land is irrigated for these crops, and fairly good yields are obtained. Water is obtained by pumping from wells. The water level ranges from 60 to 120 feet below the surface.

**Exeter loam.**—The surface soil of Exeter loam, to a depth ranging from 8 to 16 inches, is brown, light-brown, or, in places, slightly yellowish brown loam, gritty loam, or heavy loam. It is rich brown when wet, but in dry cultivated fields it appears slightly reddish brown. This material grades into yellowish-brown, light-brown, or, in places, slightly reddish brown slightly compact heavy loam, gritty loam, or light clay loam. At a depth ranging from 20 to 50 inches and averaging about 30 inches, this material overlies a reddish-brown indurated hardpan, in most places containing much brownish-red material that is yellowish brown when crushed. The hardpan contains much coarse sand and is cemented largely by iron and aluminum compounds. It is in general dense, contains few pore spaces, and is moderately hard. The lower part of the hardpan is somewhat less hard, less firmly cemented, less red, and more brown and yellow than the topmost 2 to 6 inches. The hardpan ranges from 10 to 25 inches in thickness, and the degree of hardness also varies. In some areas the material is

considerably softer than typical. Beneath the hardpan is the substratum of light yellowish-brown or brownish-yellow sandy loam, which is friable and contains much coarse sand. The entire soil contains some mica. It has been formed from water-laid deposits derived chiefly from granitic sources.

The surface soil generally is fairly friable and fairly easy to till; but, when cultivated under unfavorable moisture conditions, it has a tendency to clod or puddle, bake, and become very hard when dry. The soil above the hardpan is permeable to roots and water and holds a large amount of available water. The hardpan is largely impervious to water. As it cannot be penetrated by roots, the deeper roots go down to it and then spread out laterally on its surface. Before trees and vines are planted the hardpan is commonly blasted and broken, especially where it lies near the surface, so as to allow deeper penetration of roots and better moisture conditions. Once broken, this material remains in fairly good condition indefinitely. Subsoiling machinery also is used for breaking up the hardpan.

The soil above the hardpan and in the topmost 2 to 6 inches of the hardpan is noncalcareous, although it has a neutral to slightly alkaline reaction. In some places the upper part of the hardpan is slightly calcareous. The lower part is everywhere calcareous, containing lime in the form of seams or soft nodules. The substratum is slightly calcareous, but the content of lime decreases with depth. No alkali is present in any of the areas. The organic-matter and nitrogen contents are relatively low, although higher than in the San Joaquin soils.

Exeter loam occurs extensively on broad old alluvial fans and terraces. The land is flat or gently undulating, having a gentle slope to the west. The areas show practically no erosion, and the soil is favorable to extensive tillage operations. Unless leveled, the surface is characterized by broad rounded mounds and intervening more or less enclosed depressions, commonly known as hog wallows. The mounds are from 6 inches to 2 feet or more in height and from 10 to 25 feet in diameter. The material at the tops of the mounds is generally lighter textured, slightly lighter colored, and deeper to the hardpan layer than in the depressions, where the material is heavy textured, somewhat dark, and shallow over the hardpan layer. More organic matter accumulates in the depressions than on the mounds. The hog wallows are less pronounced and less numerous than in areas of the San Joaquin soils. Considerable leveling is necessary in preparing the land for irrigation, although leveling is not so expensive an operation as on the San Joaquin soils.

In places the slope is sufficient for good surface drainage, but subdrainage is greatly or wholly restricted by the presence of the impervious hardpan, so that in the rainy season the soil above the hardpan, especially in the depressions, becomes saturated and remains so for considerable periods. During the dry season the hardpan layer prevents the upward percolation of water from the lower substratum, causing the soil to be droughty.

Exeter loam occupies a fairly large total area. Extensive areas are between Richgrove and Sausalito School, between Poplar and Terra Bella, and southwest of Ducor. Smaller bodies are in the southeastern part of the area. This soil is associated with Exeter sandy loam, Madera loam, San Joaquin loam, San Joaquin clay loam, Delano clay

loam, Chualar clay loam, Greenfield sandy loam, Ducor clay, and Ducor clay loam.

Included with this soil on the map are small scattered areas in which a thin calcareous layer lies immediately above the hardpan or in which only the upper part of the hardpan is calcareous. This included soil is intermediate between Exeter loam and Madera loam. Near Richgrove and Vestal the texture ranges from loam or gritty loam to heavy sandy loam, and the material everywhere contains considerable coarse sand and much fine material. Where associated with the San Joaquin soils west and northwest of Ducor and Terra Bella, this soil is somewhat redder than typical and approaches the San Joaquin soils in color. Areas of Delano clay loam and Chualar loam, too small to show on the map, are included with Exeter loam.

The native vegetation consisted largely of grasses, with a few scattered oaks. About 95 percent of the land is in crops; the rest is used for pasture. Wheat is grown on about 85 percent of the total area, and none of the wheatland is irrigated. The general practice is to grow wheat every other year, the land being summer-fallowed during the intervening years. Fairly good yields of wheat are produced, ranging from 5 to 25 bushels an acre and averaging about 13 bushels. This is one of the best soils for dry-farmed grain, and a fair yield is nearly always assured. Other crops include oranges, grapes, deciduous fruits, and cotton, all of which are grown under irrigation, and fairly good yields are obtained. Water is obtained by pumping from wells. Increasing the organic-matter and nitrogen contents is important in this soil. This can be done by applying barnyard manure or by plowing under green-manure crops, especially legumes.

**Exeter clay loam.**—The surface soil of Exeter clay loam consists of brown or rich-brown clay loam about 12 inches thick. This grades into light-brown, slightly yellowish brown, or reddish-brown clay loam that is slightly more compact and heavier than the surface soil. At a depth ranging from 2 to 4½ feet and averaging about 3 feet, this material is underlain by a reddish-brown indurated hardpan that is very hard, dense, and impervious and is cemented largely by iron and aluminum compounds. The lower part of the hardpan is less hard, less firmly cemented, less red, and more brown and yellow than the topmost 2 to 6 inches. The hardpan ranges from 10 to 30 inches in thickness and varies in the degree of hardness. In some places it is considerably softer than is typical. The substratum beneath the hardpan consists of light yellowish-brown or brownish-yellow friable sandy loam. The entire soil contains some mica. It has been formed from old water-laid deposits derived chiefly from granitic sources.

The surface soil has a tendency to puddle or clod when worked under unfavorable moisture conditions, although generally it is not difficult to till. The soil above the hardpan is permeable to roots and water and is capable of holding a moderate quantity of available water. No roots and little water penetrate the hardpan. The material above the hardpan and in the topmost 2 to 6 inches of the hardpan is noncalcareous, although it is neutral to slightly basic in reaction; but the lower part of the hardpan is calcareous, containing lime in the form of seams. The substratum is slightly calcareous, the lime content

decreasing with depth. No alkali is present. The organic-matter content is relatively low.

Exeter clay loam occurs on broad gently sloping alluvial fans, where erosion is negligible. Unless leveled, it typically has a hog-wallow surface configuration similar to that of Exeter loam, and drainage conditions are similar to those in Exeter loam.

This soil occurs in only two small bodies, one 6 miles northwest of Porterville and the other about 2 miles northwest of Quincy School. Dry-farmed wheat is grown on all the land. Yields are about the same as those obtained on Exeter loam.

### SAN JOAQUIN SERIES

The soils of the San Joaquin series are developed on old modified unconsolidated water-laid deposits derived mainly from granitic sources, but in this area the deposits contain a mixture of basic igneous material. The surface soils are light reddish brown, reddish brown, or dull brownish red when dry and become more red when wet. The surface soils contain a fairly large proportion of coarse, gritty, and fine colloidal materials, which causes them to form a rather compact surface crust when dry. Beneath this crust the soil is friable; and, where the relief allows, surface penetration of moisture is good. The surface soil has a granular or small-cloddy structure, the aggregates being more or less angular and hard to break. In this area the surface soils of members of the San Joaquin series are about neutral in reaction.

The upper subsoil layers are reddish brown or deep brownish red when dry and more red when wet. They are heavier in texture, denser, and more compact than the surface soils and exhibit an angular, cloddy, or blocky structure. The subsoils rest on a brownish-red or red very dense cemented hardpan that is noncalcareous in the upper part, but in places it contains some lime, generally in seams, in the lower part. The heavier textured soil types generally have a $B_2$ horizon that is brownish red, heavy textured, very dense, and semicemented. It has a smooth glazed surface, in contrast to the $B_1$ horizon, which is not cemented and has a rough surface. The hardpan ranges in depth from 1 to 4 feet, and in some places, where the surface soil has been removed by leveling, it is exposed. In places the upper limit of the hardpan follows the contour of the surface; in others it is level. Where it is level, the surface soils are shallow in the depressions and fairly thick under the mounds. In a few places the contour of the hardpan varies conversely with that of the surface. The lower part of the hardpan is softer than the upper part.

The substratum below the hardpan is brown, yellowish brown, or grayish brown, and somewhat massive; and in some places it is slightly cemented. It is lighter textured and more permeable than the hardpan and generally becomes more friable with depth. In some places the substratum is slightly calcareous; in others it is not. Subsoil drainage is restricted because of the impervious hardpan layer, and during the rainy season the soil may become boggy where depressions occur. These soils occupy sloping plains with a slightly undulating or hog-wallow microrelief. The mounds range

from low scattered mounds from 1 to 3 feet high to higher more numerous mounds that occupy most of the surface. During the rainy season water collects in the depressions, making the soil very boggy; whereas the soil on the mounds may be moistened to a depth of only a few inches, owing to excessive run-off into the depressions. Large areas of the San Joaquin soils are south of Porterville and west of Terra Bella and Ducor; smaller bodies are west and north of Porterville. These soils are associated with the Madera soils which are brown strongly developed hardpan soils containing lime in the subsoils and hardpan, and with the Delano soils, which are similar to the Madera soils but lack the hardpan. San Joaquin loam and San Joaquin clay loam occur in the Pixley area.

**San Joaquin loam.**—The surface soil of San Joaquin loam is light reddish-brown or reddish-brown noncalcareous loam containing a large number of coarse sharp angular quartz grains, which give the soil a gritty feel. The surface soil has a granular or small-cloddy structure and is fairly friable but tends to crust on drying. Surface penetration of water is good. The upper part of the subsoil, beginning at a depth ranging from 6 to 18 inches, is reddish brown, noncalcareous, and fairly compact, with an angular cloddy structure. The texture is heavy clay loam or light clay. The lower part of the subsoil becomes red and more dense and compact. It consists of reddish-brown or deep reddish-brown noncalcareous partly cemented gritty clay underlain by a reddish-brown very dense iron-and-silica-cemented hardpan, which is present at a depth ranging from 1 to 3 feet and is from 2 to 3 feet thick. The lower part of the hardpan contains some lime segregated in seams. The substratum below the hardpan is brown or yellowish-brown heavy sandy loam, which is slightly cemented in spots and contains lime, both disseminated and in seams. The substratum becomes more soft and friable with depth.

San Joaquin loam is developed on old transported material mainly of granitic origin. It has a strongly developed profile with a hardpan layer cemented by precipitated colloids, sesquioxides, and silica. In this area it differs from the San Joaquin soils as mapped farther north in that it has lime in the lower part of the hardpan.

This soil occupies sloping terrace areas and has a well-defined hog-wallow microrelief. Surface drainage is only fair, owing to the irregular surface, and subsoil drainage is very poor, as it is restricted by the dense clay and hardpan layers. The surface soil contains a moderate amount of organic matter. It has a pH value of 7.0 to 7.6, but the pH values become higher with depth. Root penetration is only fair, as the roots are able to push through the surface soil but penetrate the subsoil only where cracks have formed. The native vegetation consists of grasses and shrubs, most of which have been destroyed through cultivation.

San Joaquin loam occupies the sloping plains below the foothills of the Sierra Nevada. The largest area occurs 3 miles southwest of Porterville, and numerous bodies are southwest of Strathmore, east of Porterville, and near and south of Ducor. This soil is associated with the Madera soils, the brown hardpan soils that occupy the same general topographic areas, and with the Exeter soils, which, in this section, appear to represent overwash materials on an old San Joaquin hardpan.

This soil is used mainly for dry farming, the crops being wheat and

barley with some oats. The soil is not deep enough for trees, and the cost of leveling the land and blasting through the hardpan to obtain root penetration and subsoil drainage is prohibitive in most places. Where the hardpan is blasted, trees do fairly well. Grain yields from 12 to 25 bushels an acre, depending on the seasonal rainfall. The layer of hardpan may or may not follow the surface configuration.

**San Joaquin clay loam.**—The surface soil of San Joaquin clay loam is reddish brown and becomes a deeper red when wet. It is noncalcareous and contains numerous sharp angular quartz grains. The structure is cloddy or slightly granular. The upper part of the subsoil, which begins at a depth ranging from 12 to 18 inches, is light brownish-red moderately compact noncalcareous clay loam with a lumpy or cloddy structure, the units of which have a rough surface. The lower part of the subsoil is somewhat darker, being brownish red, and it is more compact than the upper part. It consists of sandy clay having a blocky structure, the units of which have a smooth glazed surface. The subsoil rests, at a depth ranging from 24 to 36 inches, on a dense red cemented hardpan, from 1½ to 3 feet thick. The hardpan is very dense and hard in the upper part and contains a fairly large quantity of coarse angular quartz particles. Lime, in both disseminated form and segregated in seams, occurs in the lower part, and the material is somewhat softer and less dense than in the upper part. The substratum beneath the hardpan is grayish-brown compact gritty loam, which is semicemented in some places.

San Joaquin clay loam is developed on old alluvial deposits, mainly from granitic parent material. It occupies sloping or undulating plains and has a hog-wallow microrelief. The soil in the depressions generally is slightly darker and heavier than that on the mounds. When wet all the layers become more red. Surface drainage is only fair, owing to the irregular hog-wallow microrelief. Water collects in the depressions and generally remains for some time, owing to the slow penetration and poor subsoil drainage caused by the heavy clay subsoil and impervious hardpan. Roots are able to penetrate the upper subsoil layer but do not penetrate farther except where they follow cracks. The native vegetation at one time probably consisted of grasses and shrubs, but all have been destroyed through cultivation. The contour of the hardpan layer generally follows the surface configuration, and leveling of the land tends to expose the hardpan where mounds occurred, although in places the hardpan is level.

In this area two small bodies are south of Strathmore, which is in the Visalia area (*9*); two small bodies are 3 and 5 miles, respectively, northwest of Porterville; small bodies are along the main highway between Porterville and Vestal; and one fairly large body is 3 miles southeast of Sausalito School. San Joaquin clay loam is associated with San Joaquin loam and with soils of the Exeter series. Between Terra Bella and Ducor it occurs on narrow ridges that rise above areas of the Ducor soils. Presumably the Ducor soil material has been washed over old San Joaquin terraces and has been deposited in the lower areas so that San Joaquin clay loam is now exposed only on the higher ridges.

San Joaquin clay loam is used mainly for dry farming, and wheat and barley are the chief crops. In spots the surface has been leveled, the hardpan blasted, and trees planted. Where the hardpan is

*A*, Barren spots and salt-tolerant plants on Traver fine sandy loam; *B*, dry-land grain stubble on Ducor adobe clay with irrigated citrus orchard in distance.

Profile of Redding gravelly loam. Note shallow gravelly surface layer resting on cemented hardpan in which stones and pieces of gravel are embedded.

broken by blasting, trees do fairly well, but the cost of leveling and blasting is relatively high and may be prohibitive.

### REDDING SERIES

The surface soils of members of the Redding series consist of reddish-brown soils of slightly acid reaction and having a relatively high content of water-worn gravel and cobbles of mixed mineralogical composition. When moist these soils are distinctly red. The upper part of the subsoils begins at a depth of about 8 or 10 inches and is a pronounced reddish brown or dull-red slightly compact gravelly clay loam that dries out in fairly hard blocks. This layer contains considerable stone and is of slightly basic reaction. The lower part of the subsoils is brownish-red or dull-red very compact clay that forms hard blocks when dry. This material is basic in reaction, extremely high in colloids, and very plastic when wet. At a depth ranging from 15 to 28 inches, it rests on a basic cobbly hardpan composed of a large proportion of rounded cobbles and boulders cemented together by iron and silica. This material, in turn, rests on a mass of semicemented cobbles and boulders of mixed origin, containing very little finer soil material.

The soils of the Redding series are developed on old transported material deposited by the Tule River at a very early date. They have strongly developed profiles and have their source in rock materials of mixed origin. They occupy high alluvial terraces and old alluvial fan remnants from 150 to 200 feet above the present channel of the river. The relief is fairly flat but has a hog-wallow configuration of small mounds and depressions. A considerable number of loose cobbles and boulders are on the surface as well as throughout the soil mass. Run-off is slow on the tops of the terrace, and water stands in the small depressions. Subdrainage is restricted by the very heavy clay subsoil and the hardpan. These soils support a grass cover. Redding gravelly loam occurs in this area.

**Redding gravelly loam.**—The surface soil of Redding gravelly loam is light reddish-brown or rich-brown noncalcareous gravelly loam with a fairly high content of rounded gravel and cobblestones of mixed mineralogical composition. Under moist field conditions the red color is much intensified. The upper part of the subsoil begins at a depth of 8 to 10 inches and is reddish-brown or dull-red slightly compact gravelly clay loam that is fairly hard when dry. The lower part of the subsoil, beginning at a depth ranging from 12 to 18 inches, is brownish-red very compact clay that dries to hard blocks. This layer is very high in colloidal clay and is very sticky when wet. A cobbly hardpan, reached at a depth ranging from 15 to 28 inches, is composed of a large percentage of rounded cobbles and boulders cemented together by iron and silica. This rests on a mass of semicemented cobbles and large stones of mixed mineralogical composition containing a little finer soil material. Plate 4 shows the profile of this soil.

The entire soil material is noncalcareous and mildly acid to neutral in reaction. The organic-matter content is low, and the compact heavy-textured subsoil and hardpan restrict the penetration of water and plant roots. Redding gravelly loam occupies high alluvial ter-

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races ranging from 100 to 200 feet above the present channel of the Tule River. The escarpments of these terraces are fairly steep, but the tops have rather flat surfaces with a microrelief of small mounds and depressions or hog wallows. Run-off is very slow on the tops of the terraces, and water stands in the depressions after rains. Subdrainage is restricted by the heavy clay subsoil. Leveling for irrigation is difficult, owing to the presence of large stones and the danger of exposing the clay subsoil.

Small areas of Redding gravelly loam lie between Springville and Porterville near the Tule River. More than 90 percent of this soil has a cover of native grasses and is used for pasture, and a small area west of Springville is planted to citrus fruits. Artificial drainage is used in this soil to prevent and relieve poor drainage caused by an excessive amount of water in the subsoil. Extreme care must be used in irrigating this land to avoid the use of too much water. In general, this soil does not have a very high agricultural value and is best used for pasture.

### MADERA SERIES

The surface soils of members of the Madera series, to a depth ranging from 6 to 20 inches, are brown or rich brown and in the heavier soil types have a dull-gray cast. When wet they become slightly redder and darker. The surface soils are fairly friable and porous, and they break down to a cloddy and granular structure. The aggregates are hard and firm, and the surface of the soil bakes to form a thin crust in many places. These soils contain a large quantity of coarse angular quartz fragments, making them very gritty. Roots and water penetrate well, except in the heavy-textured types, where penetration of water may be slow. The content of organic matter is rather low, the reaction is neutral or slightly alkaline, and the surface soils contain lime in some places.

The subsoils are brown, dark brown, or dull reddish brown. They are heavier textured than the surface soils, plastic when wet, and fairly dense and hard when dry. They break down to hard clods and tend toward a prismatic structure. Lime is present in disseminated and segregated form. Soft nodules and seams of lime have formed, and in the lower part of the subsoils the content of lime is sufficient to cause the soil to become more friable and the aggregates more angular. Water and roots penetrate very slowly into the heavier subsoils, although they are aided by cracks and many insect burrows. The subsoils rest on a fairly soft calcareous hardpan with plates, seams, and mottlings of lime. The upper part of the hardpan is generally harder than the lower part, which contains more lime. The hardpan ranges in thickness from a few inches to 3 feet, the average thickness probably being about 2 feet. The substratum beneath the hardpan has about the same texture as the surface soil and is light grayish brown or light brown, friable, and calcareous.

The Madera soils are developed on old transported materials of mixed, but mainly granitic, origin. These soils occupy sloping to undulating plains, and the microrelief ranges from rather smooth to hummocky, or one locally known as hog wallow. In some places the mounds are numerous and of considerable size, but in others they

are low and tend to produce a slightly undulating effect. As these soils occur in a section of low rainfall, run-off is slight, although some erosion occurs on the mounds, where the finer material is washed into the depressions. Generally, the soil in the depressions is heavier and slightly darker than that of the mounds. Penetration of water is limited by the heavy subsoil and hardpan, and subdrainage is very poor. Approximately 23 percent of the area of the Madera soils is affected by alkali in moderate quantities. The native vegetation consisted mainly of grasses, shrubs, and herbs, but it has been destroyed through cultivation.

The soils of the Madera series are associated with the soils of the Lewis series, which are more or less transitional between the Madera soils in the higher plains and the Fresno soils in the lower, flatter, poorly drained areas. They are also associated with the Exeter soils, which occur under similar topographic conditions. The Exeter soils are brown noncalcareous hardpan soils, which might possibly represent an overwash on the previously existing hardpan. The Madera soils are associated also with the soils of the San Joaquin series, which are reddish-brown noncalcareous hardpan soils occurring at slightly higher elevations.

**Madera loam.**—The surface soil of Madera loam, to a depth ranging from 5 to 12 inches, is brown or light brown when dry and somewhat darker and richer brown when wet. It tends to develop a surface crust on drying but breaks down fairly easily to a granular structure. Below the crust the soil is rather friable and porous and allows fairly good penetration of water. An abundance of coarse sharp quartz particles gives the material a gritty feel. In general, the surface soil is noncalcareous; in this area, however, a large part of it is calcareous and about 23 percent contains sufficient salts to be injurious to crops. The upper part of the subsoil, to a depth ranging from 15 to 20 inches, is dark-brown or dark rich-brown compact clay loam having a somewhat prismatic or angular cloddy structure. It is calcareous, with the lime segregated in seams and soft nodules. The subsoil increases in lime content with depth and becomes slightly more friable immediately above the light-brown highly calcareous cemented platy hardpan. The hardpan is somewhat variable in color, ranging from brown to reddish brown or grayish brown, and it has white or gray lime seams throughout. It is platy and brittle, breaking under pressure, thus differing from the hardpan in the soils of the San Joaquin series, which is more dense and harder. The substratum below the hardpan is light-brown or light grayish-brown sandy loam or gritty loam, having a single-grain to small-granular structure. The substratum is calcareous and friable.

About 23 percent of this soil contains alkali. About 19 percent contains it in moderate quantities. Both white alkali and black alkali are present. This soil has a moderate content of organic matter. The soil occurs on sloping to undulating plains with a microrelief of numerous low mounds and depressions or hog wallows. Water collects and stands in the low spots and flats after heavy rains, and run-off is limited. Under a heavy rainfall some erosion takes place on the mounds. Surface penetration of water and subsoil drainage are restricted by the heavy impervious subsoil and hardpan. If the land is leveled for irrigation, the heavy subsoil

and hardpan is exposed in spots where the contour of the hardpan conforms to the contour of the surface; or where it lies horizontally the soil is shallow in the depressions and deeper under the mounds. The hardpan occurs at a depth ranging from 2 to 3 feet. The native vegetation of shrubs, herbaceous plants, and grasses has been destroyed through cultivation.

Madera loam is used mainly for dry farming, as the soil is too shallow and subsoil drainage is too poor for irrigated crops or trees. Wheat is the chief crop, and some barley and oats are grown. Yields are fair, ranging from 10 to 20 bushels an acre. Where alkali is present, the soil is used for pasture land. Part of the large body of Madera loam 5 miles northwest of Porterville contains a small quantity of alkali. The largest body of Madera loam is southwest of Poplar and northwest of Sausalito School. The western part of this area, where it joins with soils of the Fresno series, contains a moderate quantity of alkali. Small bodies are west of Ducor and Terra Bella, north of Porterville, and around Woodville. Madera loam is associated with the soils of the San Joaquin series, which are light reddish-brown hardpan soils similar in profile and occurrence to the Madera soils but lacking lime in the surface soils and upper subsoil layers. It is also associated with soils of the Lewis series, which occur in the lower flatter areas below the Madera soils and have a highly calcareous platy hardpan.

**Madera clay loam.**—The surface soil of Madera clay loam is brown or dark brown with a grayish-brown cast. It is micaceous noncalcareous clay loam having a cloddy or granular structure, the soil units being very firm and hard to break. The upper part of the subsoil, beginning at a depth ranging from 12 to 18 inches, is brown or reddish-brown slightly calcareous heavy clay loam or clay. It is dense and compact when dry and plastic when wet. The lower part of the subsoil, at a depth ranging from 18 to 30 inches, is reddish-brown or dark reddish-brown calcareous clay in which lime is segregated in seams and soft nodules. This layer is very compact and rests, at a depth of 4 to 4½ feet, on a reddish-brown dense hard calcareous hardpan having a platy structure. Seams of lime run through the hardpan. It is generally 1 to 2 feet thick and is underlain by a rather friable substratum of brown or grayish-brown calcareous sandy clay or sandy loam.

Madera clay loam occurs on slightly sloping relief with a low rolling hog-wallow microrelief. In small areas the mounds have been leveled, thereby making irrigation possible. Surfacve drainage under natural conditions is poor, as the water collects in depressions and stands for some time. Subsoil drainage is restricted by the heavy clay subsoil and impervious hardpan. Although the depth to the hardpan in most places is 3 feet or more, root penetration is not good because of the heavy-textured surface soil and subsoil. This soil is used mainly for dry farming or pasture land, and where it has been leveled a few grapevines have been planted. Only a very small area of this soil occurs in the Pixley area. The largest body is northwest of Porterville, and a small body is about 3 miles southeast of Sausalito School. This soil is associated with Madera loam and San Joaquin loam.

### LEWIS SERIES

The soils of the Lewis series lie between the Madera and the Fresno soils. The surface soils consist of a layer of light-gray generally noncalcareous vesicular friable material from ½ to 4 inches thick. A crust sometimes forms on the surface. The next lower layer is dark brownish-gray compact dense clay having a prismatic or columnar and solonetzlike morphological structure. In spots the tops of the columns are well rounded and are covered by a thin white layer of siliceous material. The prismatic or columnar structure extends to an average depth of about 8 inches, where horizontal cracking breaks the units into cubical or irregular blocks. The upper part of the columns, which are from 1 to 2½ inches in diameter, is generally noncalcareous, but the lower part contains some lime. Below this is light yellowish-gray or pinkish-gray highly calcareous fairly compact lighter textured material. Lime is present in seams and soft nodules, and part of the layer is slightly cemented in places. The next layer, ranging in thickness from 2 to 5 feet, is a light yellowish-gray or light brownish-gray lime-cemented platy hardpan, which is fairly soft and generally not more than 1 foot thick. It breaks rather easily into very hard plates and lumps, the breakage following lime seams and cracks. Below the hardpan is light yellowish-gray or brownish-gray calcareous semicemented medium-textured material, which becomes less cemented and more friable with depth.

The soils of the Lewis series are developed on old transported materials, have strongly developed profiles, and show a solonetzlike structure. The parent material is derived mainly from granitic sources. These soils occur on fairly flat plains between the more sloping higher plains of the Madera soils and the lower flatter areas of the Pond and Fresno soils. They have a moderate to strongly developed hog-wallow microrelief. Run-off and subdrainage are very poor, and the organic content is low. These soils support a fairly good growth of grass on top of the mounds during wet years, but the sides of the mounds are in general bare slick spots. Most of the soil in the depressions is slightly heavier than that on the mounds, and it produces a fair amount of grass. Both the surface soil and the subsoil contain harmful quantities of salts, much of which is sodium carbonate. These soils are used only for pasture, as the very poor drainage and alkali content make them unfit for cultivated crops. During good years the pastures rent for 25 to 75 cents an acre.

**Lewis fine sandy loam.**—The surface soil of Lewis fine sandy loam, typically a thin layer from ¼ to 4 inches thick, consists of light grayish-brown or brownish-gray fine sandy loam. Even this thin surface layer is not present in all places, but where present it is calcareous in some places and forms a slightly laminated vesicular crust, which breaks down to a friable consistence very easily under slight pressure. Owing to hog-wallow relief, salt content, and erosion, slick spots occur on top of the mounds and on the slopes where much of the sandy material has washed away, thereby exposing the heavy clay subsoil. The upper part of the subsoil is dark grayish-brown clay having a prismatic or columnar solonetzlike structure. In some places where the profile is well developed, the tops of the

columns are well rounded and have a thin light-gray siliceous covering. This layer generally is noncalcareous. The units of the prisms or columns are approximately 1 or 2 inches in diameter and extend to an average depth of 12 inches. Below this material the color becomes more brown and the structure blocky. Lime occurs in soft nodules and seams. The lower part of the subsoil is light yellowish-gray, light yellowish-brown, or reddish-brown rather compact fine sandy loam or loam, slightly cemented in spots. It rests on a light yellowish-gray highly calcareous lime-cemented platy hardpan. The substratum beneath the hardpan consists of light yellowish-gray, light grayish-brown, or reddish-brown calcareous massive semicemented loam, which becomes less cemented and more friable with depth.

This soil occurs in flat poorly drained areas. Owing to the irregular relief and the nearness of the heavy subsoil to the surface, cultivation is difficult and surface drainage and subdrainage are very poor. During the rainy season, water collects in the depressions and remains for long periods. It disappears mainly through surface evaporation. This soil is strongly affected by alkali. About 84 percent of its area contains a moderate quantity, and the remaining 16 percent contains strong accumulations of salts. All this soil contains black alkali (sodium carbonate). The organic-matter content is low. Grasses—mainly saltgrass, needlegrass, foxtail, and squirreltail—and similar salt- and alkali-tolerant plants compose the native vegetation. The best growth occurs on the tops of the mounds where there is a thin sandy cover, also in some of the depressions when water does not stand too long during the growing season. Numerous slick spots are bare of vegetation. This soil is used only for pasture, as the content of alkali, the relief, and drainage conditions prevent its satisfactory use for cultivated crops. During wet years when rainfall is sufficient to promote a fair growth of grass, the land rents for 25 to 75 cents an acre.

Lewis fine sandy loam is closely associated with the Fresno soils, which occur directly below the Lewis soils in lower, flatter areas, and with the Madera soils, which occur on slightly higher, more sloping, and better drained terraces. This soil seems to be transitional between the soils of the Fresno and Madera series and possesses characteristics of both. Areas occur within a radius of 5 miles northwest, west, and southwest of Sausalito School.

### FRESNO SERIES

The Fresno soils have compact gray surface soils, ranging from structureless or Solonchak soils to incipient solonetzlike soils. The surface soils are highly vesicular to a depth of about 5 inches. Many streaks of black alkali are present in the soil, and large areas of white bare spots are on the surface. They are typical Solonchak or alkali soils. The upper part of the subsoils, at a depth ranging from 10 to 30 inches, are streaked brownish gray, olive brown, rust brown, and dark brown and are very compact. This layer is underlain by a gray, olive-gray, or brownish-yellow calcareous hardpan, which is about 2 feet thick in places or consists of a succession of thin plates. The substratum is brownish-gray or grayish-yellow more sandy material. The entire mass of these soils is dense, extremely compact,

and hard to penetrate with a crowbar, even when moist. Plant roots follow old channels and cracks to the depth of the hardpan, but they do not penetrate the hardpan. This soil is rather impenetrable to moisture, owing to its compact character caused by a high content of alkali.

The Fresno soils are developed on old alluvial-fan materials derived mostly from granitic rocks. They are old soils with highly developed profiles. The surface is flat with a slope to the west of about 15 feet to a mile. Closely spaced mounds, ranging from 30 to 50 feet in diameter and about 1 foot high, with intervening depressions, give it a typical hog-wallow microrelief. Surface drainage is poor, and subdrainage is very poor. Water sometimes stands in the depressions during winter rains, but penetration of moisture is slow and the subsoils frequently remain dry. The vegetation is limited to a sparse growth of saltgrass, alkali-resistant flowering plants, such as owlclover; small desert shrubs, such as shadscale; and some sagebrush on the mounds.

The Fresno soils are closely associated with the Pond soils, from which they differ in having a cemented hardpan layer. In a few places in the northeastern part of the area the Fresno soils are associated with the Lewis soils, which have a distinct columnar or solonetzlike structure and a redder and shallower hardpan. Fresno fine sandy loam and Fresno clay loam are mapped.

**Fresno fine sandy loam.**—The 5-inch surface layer of Fresno fine sandy loam is gray compact highly vesicular calcareous fine sandy loam, which becomes nearly white when dry and very pale grayish brown when moist. It is underlain, between depths of 5 and 15 inches, by brownish-gray compact loam having a faint columnar or blocky structure. Grass roots follow the fissure planes. The texture is somewhat variable, and as mapped the type includes some areas of loam or clay loam. The material between depths of 15 and 26 inches is much like the material above, but it is more grayish brown, olive brown, or yellowish brown and has a more cloddy structure. It contains nodules of segregated lime. It passes abruptly into an indurated platy calcareous hardpan, ranging from 12 to 24 inches in thickness, which is brownish gray or light yellowish brown, streaked with rust brown, gray, and dark brown. The hardpan ranges in depth from 1 to 4 feet, and in texture from sandy clay to clay loam. It is like that in Fresno clay loam. It is underlain by brownish-gray and grayish-yellow sandy clay or silty clay to a depth of 6 feet or more. This clay has a large content of salts. It is compact and hard to penetrate with a crowbar. The entire soil is calcareous. An efflorescence of lime and saline salts appears on the surface and on the fissure planes in dry weather, and dark stains from black alkali extend downward from the surface.

It would be difficult, if not impracticable, to reclaim this soil from its alkali condition. None of it is farmed. It has a slightly higher value for grazing than Fresno clay loam, because it has fewer bare spots. Fresno fine sandy loam covers about 7 square miles, mostly in small bodies, in the northwestern and central parts of the area.

**Fresno clay loam.**—The 6-inch surface layer of Fresno clay loam is mainly light-gray rather coarse textured clay loam that is highly vesicular to a depth of about 3 inches and becomes white, puffy, in-

coherent, and structureless during dry periods. When moist it is pale grayish brown; when wet it becomes sticky, plastic, and slushy and supports but little weight and therefore becomes almost impassable for vehicles. The immediate surface soil, the upper 1- or 2-inch layer, has a slightly coarser texture than the material below, and the texture varies widely according to the hog-wallow microrelief. On the mounds the surface soil is lighter textured, and in the depressions it is heavier textured. The upper part of the subsoil is brownish-gray or light olive-brown heavy clay loam or silty clay loam, streaked with rust-brown, light-gray, and black alkali stains. As it has a faintly columnar structure, the material breaks into blocks and clodlike fragments. When dry it is very compact and is hard to penetrate with a crowbar. Plant roots follow fissure planes and old root channels. The lower part of the subsoil, between depths of 18 and 30 inches, is much like the surface soil except that it is more greenish brown or olive brown. It has more of a small-cloddy or nut structure and contains soft nodules of segregated lime. This material passes abruptly into a light grayish-yellow, intermingled with pale gray and rust brown, cemented platy heavy clay loam hardpan, ranging from 12 to 24 inches in thickness. In places the hardpan contains thin lenses of noncalcareous material. The depth to the hardpan ranges from 2 to 5 feet, and in places there are two or more successive layers of hardpan. The hardpan is difficult to shatter with a crowbar and is not penetrated by plant roots, which lie horizontally on its upper surface. Below the hardpan is variegated brownish-gray and grayish-yellow material ranging from compact silty clay to fine sandy clay or fine sandy loam, which extends to a depth of 72 or more inches. The soil material is highly calcareous throughout and effervesces freely with dilute acid. Considerable mica is present in the surface soil and upper subsoil layers. The soil is free from gravel and stone and contains very little organic matter.

All this land is strongly affected with alkali, and probably one-third of it consists of bare alkali spots covered with an efflorescence of lime and saline salts in dry weather. Tests with phenolphthalein indicate the presence of black alkali in all areas. Reclamation of this soil from alkali is impracticable at present, owing to the impermeable character of the subsoil and the lack of water, and it would be of low value even if the salts could be washed out. None of this soil is cultivated at present, although a few small areas have been farmed but have been abandoned. The soil furnishes some grazing in the spring after moist winters. Fresno clay loam is probably the least productive soil in this area. It covers about 32 square miles. The largest bodies are southwest of Earlimart.

### MISCELLANEOUS LAND TYPES

**Rough stony land.**—Rough stony land consists of rocky, stony, and steep areas, in which the relief is too steep and the soil too shallow and stony for cultivation. Included with this land type are some steep areas without stones, which would have been separated as rough broken land had they been more extensive. These steep areas contain a large quantity of material that is being continually moved down the slopes and gives rise to a fair depth

of soil material, but in many places the bedrock is exposed. Rough stony land includes areas of both coarse-textured and fine-textured igneous rocks such as produce the residual soils of the Vista, Lassen, and Las Posas series. The areas that have some soil material similar to that of the Vista soils support a cover of oak trees, whereas the soil material from finer textured rocks, such as give rise to the Lassen soils, support a cover of short grasses. Run-off is excessive.

Rough stony land occurs only east of the valley and on the stony hills that project into the valley in the vicinity of Porterville. A fairly large area is mapped. This is a nonagricultural land type and has no value for crops, although it is used for grazing.

**Rough stony land (Vista soil material).**—Rough stony land (Vista soil material) designates areas in which a shallow soil, ranging from 6 to 18 inches in thickness, overlies granitic bedrock. Large granite boulders and rounded outcrops occupy from 25 to 50 percent of the surface, so that cultivation of any sizable area is impossible. This land type occupies hilly to steep relief and is associated with Vista sandy loam, from which it differs in the slight depth of soil material, the presence of large boulders over the surface, and a rougher, steeper surface. The soil material between the boulders is of the same character as Vista sandy loam. Here and there a few spots from 1 to 3 acres in size lack the boulders and may have the same value for crops as Vista sandy loam; but, taken as a whole, this land is only used for grazing. In years of normal rainfall it supports a fairly good growth of native grasses consisting of alfileria, bromegrass, and wild oats, although these dry fairly early in the summer, owing to lack of available moisture. Much of the land is covered by a scattered growth of medium to small oak trees. Bodies of this land occur in the same districts as Vista sandy loam.

**Riverwash.**—Riverwash consists of various recent deposits of coarse sand and gravel occupying the present channel of the Tule River and, to less extent, the present channels of Deer Creek and the White River. The total area is small. The material is light gray, gray, and brownish gray, and consists chiefly of granitic materials similar to those composing the coarse-textured Tujunga soils. Overflows may occur when water is in the stream channels. Riverwash is barren of any vegetation except brush and cottonwood along the edges of the channel. Because of its coarse texture and the danger of overflow, it has no agricultural value.

## ALKALI

The term "alkali," as used in this report, refers to all the harmful soluble mineral salts that accumulate in the soil as a result of poor drainage and evaporation from the surface, in sufficient concentrations to injure plant growth. The most common of these salts are sodium chloride (table salt), sodium sulfate (Glauber's salt), sodium bicarbonate (baking soda), sodium carbonate (sal soda), calcium chloride, and magnesium sulfate.

With the exception of sodium carbonate, all these salts are classed as white alkali, because of the white crusts and efflorescence deposited on the surface of the soil by evaporation of water containing these

salts in solution. Sodium carbonate is popularly termed black alkali, because it acts on the organic material in the soil, giving rise to black crusts and stains. White alkali is less harmful than black alkali, because the latter is extremely toxic to plant growth and deflocculates or puddles the soil. Because of this puddling action, soils containing black alkali are extremely difficult to reclaim, especially if they are heavy textured, whereas white alkali is much more readily leached and removed from the soil. Naturally, the feasibility of such a practice depends on the texture of the soil, the character of the salts, and the drainage. The relative proportions of replaceable calcium and sodium in the soils play an important part in the feasibility of reclamation. Soils that have a low content of lime as compared with the content of sodium are very difficult to leach, because the soil puddles and water does not drain through it. When calcium carbonate or lime is abundant, it replaces the sodium in the absorption complex and the soil is in better physical condition. Many of the soils in the western part of Tulare County have a high content of sodium and therefore have a tendency to puddle easily.

The application of sulfur or of gypsum to the soil aids in the reclamation of black alkali land. The quantity of sulfur to apply varies according to the texture of the soil and the quantity of sodium carbonate present. Light-textured soils require less than the heavier textured soils, and soils having a high content of lime require less than those having a low content.

The location of the salts in the soil mass influences the toxic effects on crops. A concentration near the surface may prevent the growth of shallow-rooted crops; whereas, if present at a depth of 4 to 5 feet below the surface, shallow-rooted crops may not be seriously affected. Therefore, it is important to keep the alkali at sufficient depth, in order to obtain the best results with crops. This is much easier to do in soils having permeable subsoils. It is very difficult to keep the alkali down in soils having claypan subsoils, as water does not easily penetrate to the lower depths. Kelley (*5*) lists the following points to be carefully considered before proceeding to reclaim an area of alkali soil: (1) Drainage conditions; (2) composition of soluble salts; (3) content of replaced sodium in the soil; (4) nature and contents of the minerals of the soil; and (5) the composition of the irrigation water. In addition to these points, the character of the subsoil should be carefully considered, in order to determine whether it is pervious to the movement of water.

Alkali is present in sufficient quantities to be harmful or prohibitive to crop growth in nearly all of the light-colored soils in the western part of the Pixley area. Approximately 32 percent of the area is rather seriously affected with alkali, and probably another 10 percent is slightly affected or has an alkali-spotted condition.

Akali-affected areas are shown on the soil map by solid or broken red outlines, and three conditions or grades of alkali are shown by symbols. These are based on the total alkali content, the kind of alkali, and the degree to which it affects or prohibits crop growth. The natural vegetation, especially the presence of alkali-indicator vegetation, was used to assist in drawing the boundaries. The symbol A and solid red boundaries indicate areas having a high concentration

of salts, the symbol M and broken red boundaries indicate those having a moderate concentration, and the symbol S and broken red boundaries indicate those that are slightly affected or alkali spotted. The symbol F designates alkali-free areas. The location of field tests for alkali are indicated on the map by red dots. At these locations the soil was sampled and the determination of soluble salts made to a depth ranging from 4 to 6 feet. The samples were taken by horizons. The percentage of alkali present, as determined by the Wheatstone electrolytic bridge, is indicated by numbers in the form of a fraction, as $\frac{0.25}{0.40}$. The upper number gives the percentage of total salts in the air-dry soil to a depth of 1 foot; the lower number gives the average percentage of total salts to the depth sampled. The symbol B beside the "fraction" indicates the presence of black alkali.

In the strongly affected (A) areas, the growth of crops is prohibited by the high concentration of salts. Most of these areas have a native cover of alkali-indicator plants, such as inkweed, saltbush, and greasewood, and in many places the surface is covered with a white crust or efflorescence of the soluble salts. Where the sulfates are high, the surface crusts are fluffy and soft; but where carbonate of sodium is present in any quantity, the surface is hard, owing to the fact that sodium deflocculates the colloidal material in the soil. Under these conditions the soil does not absorb water, and it stands on the surface of such areas after rains. All Fresno fine sandy loam and Fresno clay loam and from 10 to 50 percent of Traver fine sandy loam, Pond loam, and Pond clay loam are strongly affected. Some of Lewis fine sandy loam also has a high content of alkali. In addition to the high alkali content, poor surface and subsoil drainage, a heavy clay subsoil and hardpan, and the high content of replaceable sodium limit the usefulness and practicability of reclamation of these strongly affected areas. Even though heavy applications of sulfur or gypsum were made, the problem of removing the soluble salts from the soil would remain, as complete reclamation depends to a large extent on good drainage.

In the areas mapped as having a moderate concentration of alkali, designated by the symbol M, the quantity is sufficiently high at present to prohibit the successful growth of most crops but not to prohibit the growth of grasses. The concentration of salts in the surface soil is lower than that occurring in the grade A areas, although the concentration in the subsoil is fairly high in places. In some places where the subsoils are permeable, the excess of soluble salts has been leached away and reclamation has proved successful. The rapidity and extent of leaching depends on the chemical character of the salts and permeability of the subsoil. No definite concentration limits were used in determining this degree of concentration, but generally the surface concentrations range between 0.5 and 0.8 percent. Although very little attempt is made to reclaim areas of either the A or the M degrees of alkali accumulation, the areas of the M degree have higher value and would be more easily reclaimed than areas of the A degree. A large percentage of the soils of the Pond and the Tulare series has a moderate content of alkali. These soils generally have a grass cover during the winter and spring, as the soluble salts are washed below the surface soil to a

depth of a few inches. In some places the growth of grass is very good in years when the rainfall is high. Soils mapped with this degree of concentration are seldom used for irrigated crops.

Slightly affected and alkali-spotted (S) areas occur in Hesperia sandy loam, in a number of the Chino soil types, and in some of the phases of the Foster and Cajon soils. The salt content in these areas ranges from 0.1 to 0.4 percent, with the salts being fairly evenly distributed through the soil mass. Crops grown in these areas are generally only slightly affected, but it must be borne in mind that at present all these lands, even though mapped as slightly spotted, present a condition of potential danger if not properly controlled. Any of these areas can be materially improved or entirely reclaimed if proper leaching methods are used. Frequent irrigations under conditions of favorable subdrainage must be practiced in order to keep the salts below the root zone. Occasionally in this grade alkali-spotted areas occur in which the concentration is fairly high in small spots but the intervening areas are relatively free of alkali. Many of the areas designated as slightly affected occur in the vicinity of Pixley, Tipton, and Earlimart. A considerable acreage of cotton and alfalfa is being grown on this grade, but practically no fruit trees or grapevines are grown.

The symbol F indicates areas that are free of alkali, such as the residual foothill soils of the Vista, Las Posas, Lassen, Diablo, and Linne series; the hardpan soils of the Exeter, San Joaquin, and Redding series; and the soils of the Hanford, Tujunga, Honcut, Greenfield, Chualar, Delano, Porterville, Hovey, and Ducor series. Most of the soils of the Foster, Cajon, and Chino series are free from injurious accumulations of salts.

## IRRIGATION AND WATER SUPPLY

Because of the low rainfall of this section and because the rainfall occurs only during the winter, irrigation is necessary for the successful production of most crops. In many parts of the area the total rainfall is not sufficient for the growth of grain hay under dry-farming methods. Therefore, because of high evaporation and lack of rainfall during the growing season of plants, it becomes necessary to apply water to the crops by artificial means. Much of the earlier agriculture of this country was centered along the river banks, where water was near the surface and where considerable water seeped from the channels. Under these conditions grasses and forage crops were able to obtain moisture during the summer. After the diversion of water for irrigation, stream flow was decreased, the underground water table became lowered by pumping from wells, and eventually it became necessary to irrigate even the forage crops, because the underground water was below reach of the plant roots. Naturally, very little moisture was available on the upland, higher fan, and terrace areas, where crops failed unless irrigated.

The 1930 Federal census reported a total of 6,239 irrigated farms in Tulare County with a total irrigated area of 410,683 acres, approximately 35 percent of which is within the area covered by this survey. The Tule River, Deer Creek, Fountain Springs, the White River, and Rag Gulch supply most of the water used in irrigation in this

area. The mean annual run-off for the Tule River is 137,000 acre-feet, from Deer Creek 18,900 acre-feet, from Fountain Springs 1,000 acre-feet, from the White River 6,300 acre-feet, and from Rag Gulch 3,500 acre-feet. This gives a total of 166,700 acre-feet of water that enters the area, and it is the mean annual quantity that can be used for surface irrigation or to replenish the underground source. Probably some additional water comes from the Kaweah River delta and from the Kern River delta along the southwestern edge. No accurate figures are available on the total acreage of crops irrigated in the area covered by this survey, although the estimated area was approximately 115,000 acres in 1929. It can be safely stated that the discharge of the streams emptying into this area is not able to maintain the underground water at a constant level under present conditions of use. This condition has resulted in the rapid lowering of the underground water level in many districts, especially those at some distance from the vicinity of the stream channels.

A number of farmers both east and west of Porterville divert water directly by gravity from the Tule River during normal years to irrigate citrus and other crops. Probably this type of service is available to 2,500 to 3,000 acres of land, and the rest of the area covered by this survey is dependent on pumps for its water supply.

The Terra Bella irrigation district was organized in 1917 to irrigate the land in the vicinity of Terra Bella adjacent to Deer Creek. A number of pumps are located along the river, water being pumped to the higher land chiefly for the irrigation of citrus orchards; and this has resulted in a very material lowering of the water table, owing to the large amount of pumping, which is greater than the replenishment. In many places the water table has receded from 25 to 40 feet within a period of 8 years.

Wells are the only source of irrigation water for land in the vicinity of Tipton and Pixley and in the southern part of the area covered by this survey. Lowering of the water table ranged from 25 to 35 feet within the period from 1921 to 1929.

The Alpaugh irrigation district, organized in 1915, obtains water from 26 wells, and approximately 3,200 acres are being irrigated at present. This irrigation district serves land within a radius of about 3 miles from Alpaugh. Approximately 2.5 feet of water an acre is being used by the crops in this district, and the water table has been lowered from 2 to 5 feet a year in recent years.

The cost of irrigation differs considerably, depending on whether the water is supplied by gravity or from wells and on the depth of the water table. Pumped water in the foothill district for citrus crops costs from $20 to $50 an acre a year. In the alfalfa- and cotton-growing districts the yearly cost ranges from $5 to $20 an acre, and in many districts the farmers have changed from alfalfa to cotton because of the increasing cost of water due to the lowering of the water table.

Citrus fruits are irrigated from March to October. The usual practice on most soils is to irrigate once each month for a period of 6 to 8 months, although more frequent applications are necessary on shallow soils. The total quantity of water used ranges from about 1.5 to 3 acre-feet, the average being about 2.5 acre-feet. The furrow system is used for applying water to most of the citrus crops,

although some farmers use the overhead sprinkling method. Deciduous fruits are irrigated in much the same way as citrus fruits; that is, by the use of furrows; but a few growers use the basin system. The average requirement of water is probably about 2 acre-feet, applied in about 4 irrigations. As a general rule, the quantity of water used on deciduous fruits is less than that used on citrus fruits as the latter are irrigated for a longer period. Probably a larger quantity is applied in each irrigation, however, on the deciduous fruits, because the soils are deeper and the roots extend to a much greater depth. Most of the good irrigators try to have the water penetrate to a depth of 5 or 6 feet on the deep alluvial soils. On the hardpan soils the number of irrigations is increased and a smaller quantity of water is given at each irrigation.

Grapes are irrigated in much the same manner as deciduous fruits, with generally a smaller quantity of water applied at a single irrigation. The total quantity of water used for grapes ranges from 2 to 3 acre-feet a year.

Alfalfa is irrigated in border checks ranging from 40 to 80 feet in width and from 250 to 1,320 feet in length. The larger checks are used on the heavier textured soils and the smaller checks on the sandy soils. The irrigating season for alfalfa extends from March to September, inclusive. About 0.5 of an acre-foot of water a month, applied in one or two irrigations, is used. On the soils that do not absorb water readily 2 irrigations each month are used, and on the deep medium-textured alluvial soils 1 irrigation of 6 inches is usually applied each month. Fron 2.5 to 4 acre-feet of water is used annually on alfalfa, the total quantity used being largely dependent on the cost of water. Where water is cheap and abundant a larger quantity is used, but at present very few growers use more than 3 acre-feet. In many districts the underground water level has been lowered to such a depth that pumping for alfalfa is not very profitable or economical at present.

A large acreage of cotton is irrigated from deep wells. Cotton is irrigated by means of furrows. A heavy irrigation of 0.5 to 0.8 of an acre-foot is usually applied before the cotton is planted, followed by 2 or 3 irrigations after the first of July. The total quantity of water used for cotton ranges from 1.5 to 3 acre-feet.

Grain sorghums, such as Egyptian corn, milo, and feterita, are given from 1 to 4 irrigations. The total use of water on these crops is probably 0.8 to 1.5 acre-feet a year. The irrigation season on these crops is relatively short.

The acreage of irrigated grain differs considerably from year to year. The quantity of irrigation water applied depends on the rainfall. Two irrigations may be necessary in a season of low rainfall, whereas one heavy irrigation may be ample in a season with normal rainfall. Relatively cheap water must be used for profitable irrigation of grain. A considerable acreage is normally irrigated in the district northwest of Alpaugh, as the soils in this district are heavy textured and hold a large quantity of water. One or two heavy applications of irrigation water are usually made.

## MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of forces of weathering and soil development on soil materials deposited or accumulated by geological agencies.

The characteristics of the soil at any given point depend on the internal soil climate, the native vegetation, the composition of the parent material, and the length of time the forces of soil development have acted on the soil material. Soil climate, in turn, depends on the usual climatic factors of rainfall, temperature, and humidity, and locally it is greatly modified by relief, as it affects drainage, aeration, and run-off.

The Pixley area is in the southeastern part of the San Joaquin Valley of California, and the soils have formed under a semiarid climate. The summers are very dry and hot, and the winters are mild and moist. Temperatures of 100° to 110° F. are not uncommon during the rainless months of June, July, and August; but the winter months have moderate temperatures with a few days when the temperature drops below 32°. The winter rains are usually gentle. From 6 to 14 inches, or an average of about 8 inches, of rain falls during the winter.

Under the prevailing type of climate, natural vegetation is dominated by short grasses and associated herbaceous plants on the lower foothills and well-drained plains and alluvial fans, moisture-loving grasses in more moist localities, and salt-tolerant plants on the alkali soils. A scattered stand of oaks covered the soils of the valley at one time, but many of these have been removed to make way for cultivated crops. The grass-covered soils have a cover crop of alfileria, bur-clover, and short grasses. These grow rapidly after the winter rains, but during the warm dry summers they dry and die or become dormant. All organic material that comes from the decomposition of these plants is chiefly oxidized and destroyed during the warm summer and fall. As a result, most of the well-drained soils are light brown, light grayish brown, or light reddish brown. On the lower lying more poorly drained soils the growth and decomposition of grasses and sedges has caused a greater accumulation of organic matter, with the result that these soils are dark grayish brown, dark brownish gray, or dark gray. The area of dark-colored soils in the Pixley area is not so great as that on the Kaweah River delta in the Visalia area. This is due to the better drainage conditions. Dark-colored soils on land that is well drained at present are due to lowering of the underground water by pumping. The soils containing harmful soluble salts are generally light gray and light brownish gray, with some dark-stained material on the soils affected with sodium carbonate.

In regard to the vertical zonality of the soils in the area covered by this survey, it is observed that the soils of the foothills and the higher alluvial terraces are brown or reddish brown, and most of the soils of the well-drained alluvial fans and flood plains along the Tule River, Deer Creek, and the White River are light brownish gray, light grayish brown, or light brown. The darker alluvial soils occupy the lower areas on the alluvial fans of these streams. The light-gray alkali soils occupy the low flat western part of the area.

Most of the soils of this area are basic in reaction, and many of them have an accumulation of lime. Many of the soils of the alluvial flood plains are calcareous throughout the entire soil mass, and a large acreage of soils in the western part of the area contains soluble salts in addition to lime. This is the result of the low rainfall of this

section, which is a region of pedocalic soils. Morphologically most of the alkali soils fall into the Solonchak classification of Gedroiz.

The texture of the surface soils in this area depends to a large extent on the kind of parent material and the processes of soil formation. The coarse-textured rocks, such as granites, give rise to coarse-textured soils, and the fine-textured rocks produce fine-textured soils. Soils located at the head of the alluvial fans are generally of coarser texture than those at the foot of the same fans.

Some of the soil series and types recognized in the Pixley area present apparent conflicts in mapping and classification with those of the earlier reconnaissance survey of the Middle San Joaquin Valley (*4*). The purpose of the earlier survey was to obtain information of a general character, covering a large part of the country within a short time. The maps were drawn on a small linear scale, and for practical purposes the soils were classified into several relative or closely associated series and groups. In the Pixley area a smaller area is mapped in much greater detail, and the classification is the result of much more intensive field and technical study. A second factor in creating apparent conflicts in classification is the result of field study, the amassing of information, and natural development in the science of soils and their classification since the date of the earlier surveys, which have caused the recognition of many new soil series and the dividing of former combined soil series into two or more individual series defined on a more detailed and more accurate scientific basis.

The soils of the Pixley area may be included in four more or less distinct groups based on degree of profile development and physiographic occurrence. These are shown on the sketch map (fig. 2) and indicated in table 7, p. 19. They are: (1) Soils with bedrock substrata, which occupy the foothill areas; (2) soils with permeable subsoils, which occupy smooth gently sloping recent and young alluvial fans and flood plains; (3) soils with slightly to moderately dense to dense subsoils, which occupy sloping to flat older alluvial fans, terraces, and valley plains; and (4) soils with hardpan substrata, which occupy sloping to flat older alluvial fans, terraces, and valley plains with hog-wallow microrelief.

Soils with bedrock substrata of the foothill and mountainous districts are developed on consolidated parent bedrock occurring at various depths below the surface. As they occupy slopes, erosion is more or less active and keeps pace with weathering of the rocks. The soils are in a young or immature stage of soil development. The surface soils, especially in the heavier textured types, have a somewhat granular structure and are fairly friable but have a very small content of organic material. The subsoils are generally very slightly heavier textured and more compact than the surface soils. They break into chunks or blocks when dry. In most places the material in the subsoils grades into the disintegrating bedrock. Fragments of the parent bedrock generally occur in the lower parts of the subsoils. As they are in a section where the annual rainfall is low, the rocks have not weathered to a very great depth; therefore the soils are shallow. For the most part the surface soils of the soils of this group are slightly basic and the subsoils are more basic. This group includes soils of the Vista, Las Posas, Lassen, Diablo, and Linne series. The

Vista, Las Posas, and Lassen soils are brown, chocolate brown, or light reddish brown, and the Diablo and Linne soils are dark brownish gray or black.

A representative profile of the soils of the foothills is shown in Vista sandy loam. The 1- to 2-inch surface layer consists of light-brown or light grayish-brown sandy loam containing considerable grass roots. Immediately below this the $A_2$ horizon, to a depth of about 10 to 14 inches, is brown sandy loam that is fairly loose when moist and contains large quantities of small mica and quartz particles. The surface soil has a pH value of 7.0 or more but is not calcareous. The subsoil consists of brown or very light reddish-brown slightly compact micaceous gritty loam or sandy loam. In the dry state, the loam material generally breaks into blocks and in many places contains fragments of granitic bedrock. The subsoil is slightly basic in reaction but does not show carbonates when tested with dilute hydrochloric acid. Analysis shows a slight accumulation of colloidal material in the subsoil. In some places a brown noncalcareous sandy clay loam layer rests on the top of the disintegrating bedrock, which lies at various depths below the surface, probably at an average depth of about 2 feet. The Vista soils are developed under a fairly low rainfall (from 9 to 18 inches annually). In the areas of the earlier reconnaissance surveys, these soils were included with the Holland series. The Holland soils as now recognized occur where the rainfall is higher.

Soils of the Las Posas series are developed on fine-grained igneous and altered parent rocks, such as amphibolites. The surface soils are light brownish red, and the subsoils are somewhat reddish brown, slightly more compact than the surface soils, and basic in reaction. The subsoils rest on bedrock at a depth ranging from 1 to 3 feet (pl. 1, *B*). Most of the Las Posas soils are relatively shallow. In an earlier reconnaissance survey these soils were classified in the Olympic and Sierra series. The Las Posas soils as mapped in this area are somewhat red and lack the lime in the subsoils of the related Lassen soils.

The Lassen soils are chocolate brown. They rest on fine-textured basic igneous bedrock (pl. 2, *A*). Both the surface soils and the subsoils are heavy textured, and the soil material breaks to a typical blocky structure. The surface soils are normally noncalcareous, but the lower part of the subsoil and the topmost part of the bedrock generally contain lime. The Lassen soils were classified with the Olympic series in the earlier reconnaissance surveys.

The Diablo soils have dark-gray or black noncalcareous surface soils. The subsoils have a somewhat heavier texture than the surface soils, are fairly compact, and contain lime incrustations. Lime normally becomes more abundant with depth. Bedrock, which consists of shale or a conglomerate type of rock, occurs at an average depth of about 40 inches.

The Linne soils are developed on calcareous shales and soft impure limestonelike materials. They have gray calcareous surface soils and highly calcareous subsoils.

The permeable soils of the alluvial fans and flood plains are represented by soils differing in color, mineralogical composition,

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lime content, drainage, and profile. These characteristics depend to a great extent on the parent material and the time that has elapsed since they were deposited by running water. The unmodified brown alluvial soils are classified in the Hanford and Honcut series.

Under virgin conditions, the Hanford soils have brown or light-brown surface soils that in the upper part appear somewhat grayish brown, owing to the presence of organic matter. The surface soils are friable, are highly micaceous, and contain a considerable quantity of small quartz fragments. Permeable stratified alluvial material derived from igneous rocks makes up the subsoils and the unconsolidated substratum. The surface soils and subsoils are neutral to slightly basic in reaction.

The Honcut soils are very similar to those of the Hanford series but are brownish red or reddish brown. As they are derived primarily from igneous rocks that are basic, the soil material is lower in content of mica and quartz than that of the Hanford soils. Both the surface soils and the subsoils are slightly basic in reaction. These soils were classified with the Hanford series in the early reconnaissance survey.

The Greenfield soils are similar to the Hanford soils in that they are brown and have a high content of mica and quartz, but they differ from those soils in having slightly more compact and slightly heavier textured subsoils. They represent a young stage in soil development, being slightly older than the Hanford soils but not so well developed as the Ramona soils, which occur in the Visalia area (*9*). The subsoils contain a slight accumulation of colloidal clay and have a soft cloddy structure. The Greenfield soils occupy the same type of relief as the related Hanford soils. In this area they contain considerable coarse grit, an outwash from the Ducor and Chualar soils, which occur east of Richgrove. The reaction of the Greenfield soils is about neutral to slightly basic.

The light-colored alluvial soils having unmodified profiles are included in the Tujunga and Cajon series.

The Tujunga soils represent very recent deposition of granitic materials. They are very low in organic matter and are light gray or light brownish gray. The subsoils have about the same color and generally a somewhat coarser texture than the surface soils. These soils are related to the Hanford soils but are lighter colored. They differ from the Cajon soils in being noncalcareous. The Tujunga soils are very coarse textured. They occupy positions very close to the channels of the Tule River, Deer Creek, and the White River.

As mapped in this area, the Cajon soils differ from the Tujunga soils in that they are calcareous. They are associated with the Foster soils on the delta of the Tule River but are lighter colored. The Cajon soils in this area probably have a little darker color and possibly show a little more mottling in the subsoil than do the typical Cajon soils mapped in the Mojave Desert.

The darker colored recent alluvial soils are classified in the Foster series. The surface soils are dull to darker brownish gray, fairly or moderately calcareous, and highly micaceous. The subsoils are light grayish brown and contain less lime than the surface soils. They are stratified and rest on micaceous soil material of sandy texture. The lime content of the surface soils ranges from 1 to 6 percent. This

is an old established series of soils, the members of which are associated with the related Chino soils.

The Chino soils occupy a lower lying position than the Foster soils, are not so well drained, and have heavier textured and more compact subsoils with accumulated lime. Following is a description of a profile of Chino fine sandy loam, which is representative of these soils:

A. 0 to 12 inches, dull-gray calcareous fine sandy loam.
$B_1$. 12 to 29 inches, brownish-gray calcareous fine sandy loam, which is probably a little more compact than the surface soil.
$B_2$. 29 to 48 inches, dark brownish-gray compact sandy clay loam, mottled to some extent with brown and yellow iron stains. When dry the soil material breaks into cubical blocks. The material in this horizon shows evidence of some accumulation of colloidal clay.
C. 48 to 72 inches, light brownish-gray calcareous loam, darker when wet. It has a high content of mica.

The Hesperia soils have light-brown or light grayish-brown noncalcareous highly micaceous surface soils, underlain by subsoils that are very slightly compact and contain lime, which is fairly evenly distributed throughout the subsoil mass. The subsoils generally are slightly heavier textured than the surface soils. The material in all horizons has a high content of mica and quartz, indicating that these soils are derived from outwash materials, chiefly of granitic origin. The lower part of the subsoils generally is lighter brown or light grayish brown, slightly calcareous, and more friable than the upper part. As occurring in this area, these soils appear somewhat yellow. The Hesperia soils are associated with the Hanford and Cajon soils. They differ from the Cajon soils in having less lime in the surface soils and in having more compact subsoils, and from the Hanford soils in having more compact subsoils with accumulated lime. The Hesperia soils are recognized in the San Joaquin Valley for the first time in this survey.

The soils of the Delano, Porterville, Chualar, and Hovey series, occurring on the alluvial fans or flood plains, have undergone moderate profile development, as evidenced by the heavier textured and more compact subsoils and by a fairly heavy accumulation of lime in the subsoils.

The Delano soils have brown or light-brown noncalcareous surface soils and subsoils that are about the same color but are moderately compact and somewhat heavier textured than the surface soils and contain accumulations of lime. The substratum consists of brown or reddish-brown alluvial deposits that contain less lime than the subsoils. The Delano soils are derived chiefly from granitic outwash. These soils appear slightly more developed than the related soils of the Hesperia series.

The soils of the Porterville and Hovey series have about the same general sequence of soil horizons, are derived from the same general kind of parent material, and have moderately developed profiles, with a nodular accumulation of lime in the subsoils.

The surface soils of members of the Porterville series are dark chocolate brown and heavy textured. When dry they develop a typical adobe structure with large blocks, 12 to 16 inches in diameter, that break down further into small cloddy and granular aggregates. At a depth of about 16 inches a nodular accumulation of lime begins. This horizon breaks into blocks that are underlain, at a depth ranging

from 30 to 50 inches, by reddish-brown or yellowish-brown calcareous clay. The Porterville soils occupy alluvial fans adjacent to the foothills, which are underlain by fine-textured igneous rocks, from which the parent materials of the Porterville soils are derived.

The soils of the Hovey series are dark, heavy textured, and slightly to moderately calcareous. The subsoils are heavy textured and contain from 10 to 20 percent of lime. The lower subsoil layers generally are light colored and high in accumulated lime. These soils are derived from basic igneous outwash, similar to that giving rise to the Porterville soils. They occupy low-lying areas subject to overflow and are high in content of organic matter.

The Chualar soils have dark grayish-brown or dark dull-brown noncalcareous surface soils with a large content of small quartz fragments. The subsoils are dark grayish brown or dark brown, fairly compact, heavier textured than the surface soils, and noncalcareous. The substratum is composed of unconsolidated sediments, mainly of granitic origin. These soils occupy small narrow valleys below the Ducor soils and represent outwash from the Ducor soils.

The Ducor soils occupy the higher undulating terraces and valley plains southeast of Terra Bella in the extreme southeastern part of the area. The surface soils are dark brown. The upper parts of the subsoils are dark grayish brown, are fairly compact, and contain considerable lime; the lower parts are richer reddish-brown than the upper parts, are very compact, and have a high lime content. Light-brown calcareous unconsolidated granitic material forms the substratum.

Table 9 gives the results of mechanical analyses of samples of several layers of a profile of Ducor clay, as observed about 1 mile north of Success, in sec. 13, T. 21 S., R. 28 E. These analyses were made in the laboratories of the Division of Soil Chemistry and Physics.

TABLE 9.—*Mechanical analysis of Ducor clay from the Pixley area, Calif.*

| Sample No. | Depth | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | *Inches* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 5786142 | 0–12 | 2.4 | 4.3 | 3.6 | 7.8 | 6.0 | 26.5 | 49.4 |
| 5786143 | 12–22 | 2.5 | 4.7 | 3.6 | 7.4 | 6.5 | 26.2 | 49.1 |
| 5786144 | 22–34 | 2.0 | 4.9 | 3.6 | 7.5 | 6.4 | 27.2 | 48.4 |
| 5786145 | 34–46 | 2.0 | 4.3 | 3.9 | 8.7 | 7.4 | 28.5 | 45.2 |

Closely associated with the Porterville, Delano, Chualar, Ducor, and Hovey soils in stage or degree of profile development, but developed in lower lying flat areas of poorly developed drainage, are the Pond, Waukena, Tulare, and Hacienda soils. They contain saline and alkali salts and support a natural vegetation dominated by salt-tolerant plants.

The soils of the Pond series have light-gray or light brownish-gray calcareous surface soils and light-gray or light brownish-gray moderately compact calcareous subsoils that are heavier textured than the surface soils. The substratum is light-gray or light yellowish-gray micaceous stratified material of variable texture. The entire soil mass is highly micaceous. These soils have the morphology of the Solonchak. The Pond soils are associated with

and have the same type of microrelief as the related Fresno soils, but they differ in that the cemented silty hardpan lenses, which are present in the Fresno soils, are lacking in the Pond soils.

The Waukena soils have light brownish-gray vesicular and platy thin surface soils, underlain abruptly by brownish-gray noncalcareous dense columnar solonetzlike subsoils, grading into lighter colored more friable calcareous material.

The Tulare soils are developed on sediments laid down by the waters of old Tulare Lake, which has since receded. The surface soils are gray or dull brownish gray, and the subsoils are fairly compact and of silty clay or clay texture. Considerable mottling with lime and iron stains is present in the subsoils. The subsoils contain much lime, which is segregated in large soft nodules and seams. The lower parts of the subsoils and substrata are normally heavy textured. In most places seams of sandier material lie within 5 feet of the surface. The Tulare soils are of mixed mineralogical composition, although they have a high content of mica and many fragments of mussel shells, which contribute to the content of lime. The surface soils may be relatively free of soluble salts, but the subsoils generally contain considerable alkali.

The Hacienda soils have developed on materials of the Tulare soils, with which they are associated and from which they are distinguished by tough, dense, abrupt columnar solonetzlike subsoils.

Soils with cemented hardpan substrata include the soils of two groups, which differ in color, character of hardpan, physiographic occurrence, and relief. Of these, the Exeter, San Joaquin, Redding, and Madera soils are brown or reddish brown, are underlain by dense brown or reddish-brown hardpan layers cemented by sesquioxides and silica, and are developed on the more elevated valley plains, old alluvial fans, and terraces. The surface soils are typically neutral to mildly acid in reaction, and they are generally free from accumulated saline or alkali salts. The Lewis and the Fresno soils are light-colored and calcareous and have lime-cemented hardpan layers.

The members of the Exeter series have brown micaceous surface soils, resting on light reddish-brown or light yellowish-brown slightly compact subsoils of somewhat heavier texture, at a depth ranging from 16 to 20 inches. These soils are noncalcareous and are moderately or slightly alkaline in reaction. A silica-and-iron-cemented hardpan occurs at a depth of about 30 to 40 inches. It is from 9 to 24 inches in thickness and grades into light grayish-brown fairly compact sandy loam. The Exeter soils are derived from rock material, mainly of acid igneous origin, and occupy sloping terraces or old alluvial fans. The soil material above the hardpan is similar to that of the Greenfield or Ramona soils. In the earlier reconnaissance surveys they were classified with the Madera soils.

The soils of the San Joaquin series are the best known hardpan soils of this group. Following is description of a profile of San Joaquin loam, representative of the series in this area:

A. 0 to 16 inches, light reddish-brown noncalcareous loam that becomes fairly hard and breaks up cloddy on drying. It contains considerable quartz.

$B_1$. 16 to 24 inches, reddish-brown noncalcareous fairly compact heavy clay loam that breaks into fairly hard clods when dry and shows considerable colloidal staining on the surface of the clods.

$B_2$ 24 to 34 inches, very dark reddish brown iron-and-silica-cemented hardpan. The topmost 2 or 3 inches of the hardpan is noncalcareous, but the lower part contains lime in small quantities. The lower part is somewhat softer than the upper part. The hardpan is composed of fine-textured soil material, although considerable quartz fragments are embedded in it.

C. 34 to 48 inches, brown or yellowish-brown heavy-textured sandy loam. This material is compact in place but can be pulverized between the fingers. It contains considerable quartz.

The San Joaquin soils are derived from transported material that has its origin mainly in the coarser textured igneous rocks. Soil development over a long period of time has produced the hardpan and the claypan above it.

The Redding soils are developed on old alluvial terrace materials occurring along the Tule River. They have cobbly hardpan layers. These soils are derived from material of mixed geological origin. The surface soils are light reddish brown, are noncalcareous, and contain a considerable quantity of rounded gravel and stone. The subsoils are brownish red, very compact, and extremely heavy textured. The colloidal clay content is extremely high in the subsoils. The subsoils rest on iron-and-silica-cemented cobbly hardpan layers that occur at a depth ranging from 15 to 30 inches below the surface (pl. 4). The hardpan ranges from 1 to 2 feet in thickness and rests on a mass of semicemented gravel and cobbles of mixed geological origin. The entire soil mass is noncalcareous but has a pH value of 7.2 to 7.7.

The Madera soils are related to the San Joaquin soils, but they are browner, contain lime in the subsoils, and have hardpans that carry considerable lime in seams and cracks. The hardpan in the Madera soils generally is not so hard as that in the San Joaquin soils. The Madera soils occupy a place between the San Joaquin and Lewis soils, both in regard to general characteristics and to location. As mapped in this area, the Madera soils contain more lime in the subsoils and have softer hardpans than the Madera soils farther north in the San Joaquin Valley.

The soils of the Lewis series occur between the Madera and Fresno soils, both in location and in general characteristics. They have light-gray surface soils that are vesicular when dry. At a depth ranging from 2 to 5 inches, distinct brownish gray very compact clay of columnar structure is reached, the upper 2 or 3 inches of which is dark-colored. Roots do not penetrate the columns. The underlying soil material is browner and breaks into hard cubical blocks. At a depth ranging from 24 to 30 inches, this material rests on yellowish-brown loam that is extremely high in lime. This, in turn, rests on yellowish-gray or grayish-yellow soil material that also is high in lime. The calcium hardpan layers range from 3 to 12 inches in thickness. Composed of heavy-textured lime-cemented material, the hardpan lies from 3 to 4 feet below the surface. The soil material below the hardpan is yellowish-gray, light grayish-brown, or brown calcareous loam or clay loam. Although somewhat mixed in mineralogical composition, the Lewis soils contain a relatively high proportion of mica. In many places the Lewis soils seem to represent a Solonetz development of the Fresno soils. They contain a high content of black alkali, especially in the subsoil.

The Fresno soils are light gray. Their subsoils are only slightly heavier in texture than the surface soils, but they have cemented silty clay hardpan layers at a depth of 2 to 3 feet. These lenses generally are from 1 to 3 inches thick and alternate with layers of other soil material. The entire soil mass is high in lime, is very micaceous, and has a high content of soluble salts. The Fresno soils have developed under poor drainage and an accumulation of soluble salts of sodium and calcium. The silty hardpan layers no doubt were deposited in the small depressions in the process of soil building, and, after deposition, probably were cemented by sodium and calcium carbonates. These soils are low in organic matter and contain many sharp particles of silica. They are developed on alluvial outwash material. The presence of black alkali has deflocculated these soils, yet they do not have the Solonetz morphology of the related Lewis soils. In general, the morphological characteristics of the Fresno soils seem to be definitely Solonchak, yet they carry considerable black alkali.

## SOIL RATINGS

In table 10 the soils of the Pixley area are evaluated on a percentage basis by means of the Storie index (*8*).

TABLE 10.—*Rating of the soils of the Pixley area, Calif.*

| Soil type | Rating | Grade |
|---|---|---|
| Cajon fine sandy loam (alkali free) | 100 | 1 |
| Foster fine sandy loam (alkali free) | 100 | |
| Foster loam | 100 | |
| Hanford loamy fine sand | 100 | |
| Hesperia loam (alkali free) | 100 | |
| Chino fine sandy loam (alkali free) | 95 | |
| Greenfield sandy loam | 95 | |
| Hanford sandy loam | 95 | |
| Hesperia sandy loam (alkali free) | 95 | |
| Foster loamy sand | 90 | |
| Honcut loam | 90 | |
| Chino loam (alkali free) | 86 | |
| Chino sandy loam | 86 | |
| Chualar clay loam | 85 | |
| Hanford loamy fine sand, shallow phase (over Madera soil material) | 80 | |
| Chino fine sandy loam (slight alkali) | 76 | 2 |
| Chino loam (alkali spotted) | 76 | |
| Hesperia sandy loam (slight alkali) | 76 | |
| Cajon fine sandy loam (slight alkali) | 75 | |
| Cajon fine sandy loam, shallow phase (over Madera soil material) (alkali free) | 75 | |
| Foster fine sandy loam (slight or spotted alkali) | 75 | |
| Foster fine sandy loam, shallow phase (over Madera soil material) (alkali free) | 75 | |
| Hesperia loam (slight alkali) | 75 | |
| Chino clay loam (alkali free) | 73 | |
| Cajon sandy loam (alkali free) | 72 | |
| Cajon sandy loam, shallow phase (over Chino soil material) | 72 | |
| Cajon fine sandy loam, shallow phase (over Pond soil material) (slight or alkali spotted) | 72 | |
| Delano clay loam | 72 | |
| Traver fine sandy loam (slight alkali) | 72 | |
| Ducor clay loam | 68 | |
| Tulare clay loam (slight alkali) | 68 | |
| Exeter sandy loam | 67 | |
| Tujunga sandy loam | 67 | |
| Chino loam, shallow phase (over Madera soil material) (alkali free) | 66 | |
| Cajon sandy loam (slight alkali) | 65 | 2 |
| Chualar sandy clay loam | 65 | |
| Cajon fine sandy loam, shallow phase (over Madera soil material) (slight alkali) | 64 | |
| Foster fine sandy loam, shallow phase (over Madera soil material) (slight alkali) | 64 | |
| Chino clay loam, shallow phase (over Fresno soil material) (alkali free) | 62 | |
| Cajon sandy loam, shallow phase (over Madera soil material) (alkali free) | 61 | |
| Cajon sandy loam, shallow phase (over Chino soil material) (slight alkali) | 58 | 3 |
| Chino clay loam (slight alkali) | 58 | |
| Ducor adobe clay | 56 | |
| Ducor clay loam, rolling phase | 56 | |
| Chino loam, shallow phase (over Madera soil material) (slight alkali) | 53 | |
| Ducor clay | 51 | |
| Porterville adobe clay | 51 | |
| Tulare very fine sandy loam (slight to moderate alkali) | 51 | |
| Chino clay loam, shallow phase (over Fresno soil material) (slight alkali) | 50 | |
| Chualar sandy clay loam, shallow phase (over San Joaquin soil material) | 50 | |
| Exeter loam | 50 | |
| Cajon sandy loam, shallow phase (over Madera soil material) (slight alkali) | 48 | |
| Tujunga sand | 48 | |
| Chualar clay | 46 | |
| Hovey adobe clay | 46 | |
| Ducor adobe clay, rolling phase | 45 | |
| Exeter clay loam | 43 | |
| Las Posas clay loam | 43 | |
| Vista sandy loam | 43 | |
| Linne clay | 42 | |
| Madera loam (alkali free) | 40 | |

TABLE 10.—*Rating of the soils of the Pixley area, Calif.*—Continued

| Soil type | Rating | Grade |
|---|---|---|
| Traver fine sandy loam (moderate alkali) | 36 | |
| Cajon fine sandy loam (moderate alkali) | 35 | |
| Madera clay loam | 34 | |
| Tulare very fine sandy loam (moderate alkali) | 34 | |
| Foster fine sandy loam, shallow phase (over Madera soil material) (moderate alkali) | 32 | |
| Madera loam (slight alkali) | 32 | 4 |
| Cajon sandy loam (moderate alkali) | 29 | |
| Chino clay loam (moderate alkali) | 29 | |
| San Joaquin loam | 25 | |
| Lassen clay | 24 | |
| Waukena fine sandy loam (moderate alkali) | 24 | |
| Tulare clay loam (moderate alkali) | 22 | |
| Tulare fine sand (moderate alkali) | 22 | |
| San Joaquin clay loam | 21 | |
| Diablo adobe clay | 20 | |
| Las Posas stony clay loam | 19 | |
| Pond loam (moderate to fairly high alkali) | 18 | |
| Hacienda fine sandy loam (moderate alkali) | 17 | 5 |
| Porterville stony adobe clay | 17 | |
| Tulare loam (moderate to high alkali) | 17 | |
| Madera loam (moderate alkali) | 15 | |
| Pond clay loam (moderate to fairly high alkali) | 15 | |
| Redding gravelly loam | 15 | |
| Tulare clay (moderate to high alkali) | 15 | |
| Rough stony land (Vista soil material) | 14 | |
| Fresno fine sandy loam (moderate alkali) | 12 | 5 |
| Lewis fine sandy loam (moderate alkali) | 12 | |
| Tujunga stony sand | 12 | |
| Lassen stony adobe clay | 11 | |
| Cajon fine sandy loam (strong alkali) | 10 | |
| Traver fine sandy loam (high alkali) | 7 | |
| Waukena fine sandy loam (high alkali) | 6 | |
| Pond loam (high alkali) | 5 | |
| Tulare clay (high alkali) | 5 | |
| Tulare loam (high alkali) | 5 | |
| Fresno clay loam (high alkali) | 4 | |
| Fresno fine sandy loam (high alkali) | 4 | 6 |
| Lewis fine sandy loam (high alkali) | 4 | |
| Madera loam (high alkali) | 4 | |
| Pond clay loam (high alkali) | 4 | |
| Hacienda fine sandy loam (high alkali) | 3 | |
| Rough stony land | 2 | |
| Riverwash | 2 | |

The Storie index includes a weighing of such soil characteristics as depth, texture, density of the surface soil and the subsoil, reactions, alkali content, and drainage conditions. This index rating is based solely on soil characteristics, in which local weather conditions, availability of irrigation water, and other factors are not considered. It is a comparison of the soils in this area with other soils of California, irrespective of location.

On the basis of the index rating, the soils are placed in six grades. Soils having an index rating of 80 to 100 percent are placed in grade 1. The soils of this grade are considered to be of excellent quality and suitable for a wide range of crops. Grade 2 soils (index rating between 60 and 79 percent) are of good quality and suitable for most crops. Grade 3 soils (index rating between 40 and 59 percent) are somewhat limited in their use by extremes of texture, by drainage, by heavy-textured subsoils, or by other soil factors. Some soils in this grade may have special adaptation value for certain crops. Grade 4 soils (index rating between 20 and 39 percent) are suitable for few crops except grasses and shallow-rooted crops, or possibly alkali-tolerant plants where alkali is the limiting factor. Some soils in grade 4 may be raised to grade 3 by means of alkali reclamation, leveling, blasting hardpan, or other practices, and some individual areas would be rated higher. Grade 5 soils (index rating of 10 to 19 percent) generally are of very poor quality for any cultivated crop. Grade 6 soils (index rating of less than 10 percent) are nonarable or nonagricultural.

## LABORATORY STUDIES[9]

### MECHANICAL ANALYSES

Mechanical analyses of samples of all the surface soils were made by a proximate method, in which the air-dried soils were screened through a 2-millimeter sieve, the lumps being crushed and the particles coarser than 2 millimeters rubbed comparatively clean. The screened soil was shaken in distilled water with ammonia as a dispersant, then washed through a 300-mesh sieve to remove the sands, which are reported as total sands. The silt and clay suspension, which passed through the sieve, was made up to volume, allowed to stand, and sampled by the pipette at the proper time intervals to give effective maximum diameters of silt at 50 microns, clay at 2 microns, and colloid at 1 micron. The results of these unpublished analyses were used only to check the field textural classification.

Samples from 11 soil profiles were analyzed by the more complete dispersal method, whereby the soil was pretreated with hydrogen peroxide and hydrochloric acid, to remove organic matter and carbonates, and then dispersed with sodium oxalate, the subsequent manipulation being essentially the same as that just described. The results of these analyses are given in table 11.

TABLE 11.—*Mechanical analyses of samples of 11 soils from the Pixley area, Calif.*[1]

| Soil type and sample No. | Depth | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Coarse clay (5–2 μ) | Ultra clay (<2 μ) |
|---|---|---|---|---|---|---|---|---|---|
| | *Inches* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| Tulare very fine sandy loam: | | | | | | | | | |
| 578604 | 0–24 | 0.0 | 0.3 | 0.2 | 1.6 | 39.8 | 51.6 | 2.0 | 4.1 |
| 578605 | 24–34 | .1 | .4 | .4 | 3.2 | 40.4 | 41.9 | 5.9 | 8.0 |
| 578606 | 34–64 | .1 | .2 | .2 | 3.8 | 16.8 | 50.3 | 8.2 | 21.1 |
| Fresno fine sandy loam: | | | | | | | | | |
| 578644 | 0– 5 | .6 | 3.5 | 4.8 | 34.8 | 19.2 | 26.1 | 2.9 | 8.3 |
| 578645 | 5–15 | .9 | 5.7 | 7.6 | 34.5 | 19.1 | 16.4 | 3.5 | 12.3 |
| 578646 | 15–23 | .8 | 5.5 | 5.6 | 35.7 | 20.1 | 21.3 | 3.5 | 7.6 |
| 578647[2] | 23–33 | 1.5 | 9.8 | 9.8 | 32.3 | 15.1 | 20.9 | 2.6 | 7.7 |
| 578648 | 33–60 | 2.2 | 9.3 | 10.8 | 34.5 | 14.4 | 22.2 | 3.9 | 3.1 |
| Hesperia sandy loam: | | | | | | | | | |
| 578649 | 0–12 | 3.7 | 16.4 | 15.8 | 26.6 | 12.7 | 16.9 | 2.4 | 4.8 |
| 578650 | 12–42 | 2.3 | 14.8 | 14.0 | 26.5 | 16.3 | 21.4 | 2.6 | 2.2 |
| 578651 | 42–72 | 1.7 | 5.6 | 8.0 | 41.3 | 17.9 | 19.9 | 2.7 | 4.3 |
| Hanford sandy loam: | | | | | | | | | |
| 578661 | 0–16 | 7.5 | 15.8 | 8.6 | 18.4 | 20.3 | 17.7 | 1.6 | 9.8 |
| 578662 | 16–72 | 8.2 | 15.8 | 6.8 | 19.7 | 19.4 | 19.2 | 1.3 | 9.8 |
| Chino fine sandy loam: | | | | | | | | | |
| 578674 | 0–12 | .5 | 2.7 | 4.6 | 38.9 | 17.0 | 23.3 | 4.5 | 9.9 |
| 578675 | 12–29 | .5 | 3.0 | 4.8 | 42.7 | 18.9 | 19.1 | 3.2 | 9.0 |
| 578676 | 29–48 | .4 | 1.2 | 1.4 | 14.6 | 19.5 | 37.3 | 6.9 | 18.9 |
| 578677 | 48–72 | .6 | 2.4 | 1.9 | 8.2 | 12.8 | 45.5 | 9.8 | 18.7 |
| Lewis fine sandy loam: | | | | | | | | | |
| 578686 | 0– 4 | 1.7 | 5.9 | 5.0 | 21.7 | 20.5 | 30.9 | 4.4 | 8.0 |
| 578687 | 3–12 | .9 | 3.8 | 3.1 | 11.7 | 14.5 | 31.6 | 6.6 | 28.6 |
| 578688 | 12–21 | 1.1 | 3.8 | 2.6 | 12.9 | 14.0 | 36.8 | 6.6 | 23.2 |
| 578689 | 21–40 | 1.8 | 5.3 | 4.1 | 15.4 | 17.1 | 39.9 | 6.8 | 10.6 |
| 578690[2] | 40–52 | 8.9 | 20.2 | 10.9 | 25.6 | 14.4 | 14.9 | 1.8 | 4.7 |
| 578691 | 52–60 | 8.7 | 15.8 | 7.3 | 23.9 | 19.6 | 14.6 | 3.8 | 6.7 |
| San Joaquin loam: | | | | | | | | | |
| 5786103 | 0–16 | 3.5 | 8.3 | 4.3 | 13.9 | 14.7 | 35.6 | 5.6 | 15.0 |
| 5786104 | 16–24 | 3.4 | 7.8 | 4.7 | 14.6 | 13.2 | 36.3 | 5.3 | 14.8 |
| 5786105[2] | 24–34 | 10.7 | 25.2 | 12.6 | 22.3 | 12.1 | 13.2 | 1.5 | 3.6 |
| 5786106 | 34–66 | 4.8 | 10.8 | 6.8 | 21.6 | 18.6 | 27.0 | 5.2 | 6.9 |
| Ducor adobe clay: | | | | | | | | | |
| 5786138 | 0–18 | 3.7 | 6.4 | 2.9 | 8.0 | 7.2 | 28.9 | 1.8 | 39.3 |
| 5786139 | 18–24 | 3.5 | 6.5 | 3.4 | 8.0 | 7.1 | 27.0 | 4.8 | 40.8 |
| 5786140 | 24–53 | 4.5 | 7.8 | 3.9 | 7.2 | 8.3 | 24.5 | 6.6 | 38.2 |
| 5786141 | 53–62 | 10.4 | 16.4 | 6.2 | 13.1 | 8.4 | 21.4 | 5.0 | 20.2 |

[1] International method.
[2] Hardpan.

[9] This section is a contribution from C. F. Shaw, division of soil technology, University of California.

TABLE 11.—*Mechanical analyses of samples of 11 soils from the Pixley area, Calif.*—Continued

| Soil type and sample No. | Depth | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Coarse clay (5–2 μ) | Ultra clay (<2 μ) |
|---|---|---|---|---|---|---|---|---|---|
| | *Inches* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| Redding gravelly loam: | | | | | | | | | |
| 5786151 | 0–8 | 7.6 | 11.3 | 6.0 | 13.9 | 10.7 | 33.0 | 3.0 | 14.4 |
| 5786152 | 8–15 | 9.3 | 12.4 | 6.0 | 13.2 | 12.0 | 27.6 | 4.2 | 15.4 |
| 5786153 | 15–19 | 6.4 | 12.8 | 4.9 | 12.2 | 9.5 | 13.9 | 3.0 | 37.3 |
| 5786154 [2] | 19–30 | 14.3 | 26.3 | 9.8 | 18.6 | 11.2 | 13.2 | 1.9 | 5.3 |
| Vista sandy loam: | | | | | | | | | |
| 5786157 | 0–10 | 6.6 | 17.2 | 7.9 | 21.4 | 12.1 | 19.7 | 4.1 | 10.5 |
| 5786158 | 10–22 | 4.9 | 13.5 | 8.5 | 23.9 | 13.4 | 19.3 | 2.6 | 13.6 |
| 5786159 | 22–26 | 7.8 | 16.8 | 9.4 | 22.3 | 13.4 | 14.6 | 2.5 | 13.4 |
| Greenfield sandy loam: | | | | | | | | | |
| 5786183 | 0–12 | 14.2 | 21.3 | 8.7 | 12.0 | 7.7 | 21.1 | 2.8 | 12.1 |
| 5786184 | 12–40 | 12.3 | 20.9 | 8.3 | 14.5 | 9.1 | 20.1 | 2.9 | 12.0 |
| 5786185 | 40–55 | 13.9 | 19.2 | 9.4 | 15.0 | 7.3 | 15.5 | 2.0 | 17.2 |
| 5786186 | 55–70 | 18.8 | 29.6 | 10.3 | 14.9 | 5.1 | 8.3 | 1.8 | 12.8 |

[2] Hardpan.

A comparison of the results obtained by this complete dispersion method and the proximate method showed very minor differences, and in only three of the samples analyzed would it change the textural classification of the soil. These analyses bring out strikingly the very high clay content of the B horizon of Lewis fine sandy loam, which has a heavy clay subsoil with a very distinct columnar structure resembling that of the Solonetz morphological type. The zone of clay accumulation in Greenfield sandy loam is distinct, but it lies between depths of 40 and 55 inches. The clay content of the horizon above and below this horizon is remarkably uniform. Redding gravelly loam has a very striking clay accumulation just above the hardpan. This feature also generally is present in the San Joaquin soils but does not show in the San Joaquin sample, suggesting that possibly this sample is not characteristic of the San Joaquin soils as a whole.

### MOISTURE EQUIVALENTS

Moisture equivalents were determined by the standard method, by which 30 grams of saturated soil is subjected to a force of 1,000 times gravity in a centrifuge. The moisture equivalents are reported in percentage of moisture calculated on the basis of oven-dry soil. They represent approximately the normal field-moisture capacity, or the amount of water that is held in a soil after a heavy rain or an irrigation where drainage downward is free and uninterrupted. The results are shown in table 12 and do not deviate from the usual for the textures among the soils examined.

TABLE 12.—*Determinations of moisture equivalents and carbonates in soils of the Pixley area, Calif.*

| Soil type and sample No. | Depth | Moisture equivalent | Sodium carbonates [1] | Carbonates [2] |
|---|---|---|---|---|
| Tulare fine sand: | *Inches* | *Percent* | | *Percent* |
| 578601 | 0–28 | 9.08 | + | 19.35 |
| 578602 | 28–40 | 30.60 | + | 12.93 |
| 578603 | 40–72 | 44.35 | + | 7.64 |
| Tulare very fine sandy loam: | | | | |
| 578604 | 0–24 | 17.45 | ---------- | 8.64 |
| 578605 | 24–34 | 32.90 | ---------- | 16.00 |
| 578606 | 34–64 | 47.70 | + | 25.89 |
| Tulare clay loam: | | | | |
| 578607 | 0–7 | 30.20 | ---------- | 10.63 |
| 578608 | 7–38 | 52.20 | ---------- | 3.28 |
| 578609 [1] | 38–70 | ---------- | ---------- | ---------- |
| Pond loam: | | | | |
| 578610 | 0–7 | 44.50 | + | 6.72 |
| 578611 | 7–18 | 16.40 | + | 3.63 |
| 578612 | 18–58 | 13.25 | + | 2.18 |
| 578613 | 58–68 | 18.35 | + | 8.84 |
| Tulare loam: | | | | |
| 578614 | 0–7 | 25.95 | ---------- | 5.56 |
| 578615 | 7–27 | 34.24 | + | 12.13 |
| 578616 | 27–46 | 37.80 | + | 6.35 |
| 578617 [3] | 46–72 | ---------- | + | ---------- |
| Tulare clay: | | | | |
| 578618 | 0–12 | 38.55 | + | 22.78 |
| 578619 | 12–26 | 44.75 | + | 19.87 |
| 578620 | 26–60 | 50.55 | + | 20.05 |
| 578621 | 108–116 | 21.51 | + | 5.02 |
| Fresno clay loam: | | | | |
| 578622 | 0–6 | 24.76 | + | 6.49 |
| 578623 | 6–18 | 37.35 | + | 7.12 |
| 578624 | 18–29 | 44.40 | + | 5.38 |
| 578625 | 29–41 | ---------- | ---------- | 11.49 |
| 578626 | 41–72 | 22.56 | + | 4.30 |
| Pond clay loam: | | | | |
| 578627 | 0–2½ | 21.15 | + | 7.93 |
| 578628 | 2½–14 | 24.16 | + | 7.81 |
| 578629 | 14–28 | 26.09 | + | 4.63 |
| 578630 | 28–55 | 24.20 | + | 7.56 |
| 578631 | 55–72 | 22.85 | + | 4.64 |
| Traver fine sandy loam: | | | | |
| 578632 | 0–15 | 19.82 | ---------- | 1.63 |
| 578633 | 15–30 | 21.39 | + | 3.98 |
| 578634 | 30–72 | 22.19 | + | 3.80 |
| Chino clay loam: | | | | |
| 578639 | 0–10 | 29.15 | ---------- | 4.95 |
| 578640 | 10–20 | 29.34 | ---------- | 5.33 |
| 578641 | 20–30 | 28.57 | ---------- | 4.06 |
| 578642 | 30–50 | 25.81 | + | 10.24 |
| 578643 | 50–70 | 23.25 | ---------- | 1.45 |
| Fresno fine sandy loam: | | | | |
| 578644 | 0–5 | 13.57 | ---------- | 4.27 |
| 578645 | 5–15 | 17.35 | ++ | 3.67 |
| 578646 | 15–23 | 16.15 | ++ | 4.08 |
| 578647 [4] | 23–33 | ---------- | ++ | 9.37 |
| 578648 | 33–60 | 16.85 | + | 5.91 |
| Hesperia sandy loam: | | | | |
| 578649 | 0–12 | 9.71 | ---------- | .40 |
| 578650 | 12–42 | 11.17 | ---------- | 2.77 |
| 578651 | 42–72 | 11.47 | + | 4.50 |
| Traver fine sandy loam: | | | | |
| 578652 | 0–4 | 10.59 | ---------- | .81 |
| 578653 | 4–18 | 15.87 | ---------- | 3.85 |
| 578654 | 18–46 | 14.15 | + | 2.84 |
| 578655 | 46–60 | 14.78 | + | 3.93 |
| 578656 | 60–80 | 13.09 | + | 4.21 |
| Hesperia loam: | | | | |
| 578657 | 0–16 | 10.20 | ---------- | .63 |
| 578658 | 16–48 | 12.54 | ---------- | .81 |
| 578659 | 48–60 | 18.25 | ---------- | 2.60 |
| 578660 | 60–80 | 11.50 | ---------- | 1.52 |
| Hanford sandy loam: | | | | |
| 578661 | 0–16 | 9.76 | ---------- | .65 |
| 578662 | 16–72 | 9.53 | ---------- | .62 |
| Cajon fine sandy loam: | | | | |
| 578663 | 0–12 | 13.57 | ---------- | 1.91 |
| 578664 [5] | 12–72 | ---------- | ---------- | ---------- |

See footnotes at end of table.

TABLE 12.—*Determinations of moisture equivalents and carbonates in soils of the Pixley area, Calif.*—Continued

| Soil type and sample No. | Depth | Moisture equivalent | Sodium carbonates [1] | Carbonates [2] |
|---|---|---|---|---|
| | *Inches* | *Percent* | | *Percent* |
| Madera loam: | | | | |
| 578665 | 0–5 | 20.25 | | 0.51 |
| 578666 | 5–17 | 29.60 | | 2.17 |
| 578667 | 17–32 | 30.70 | + | 3.42 |
| 578668 [4] | 32–41 | | + | 17.90 |
| 578669 | 41–56 | 15.53 | | 10.20 |
| Foster fine sandy loam: | | | | |
| 578670 | 0–20 | 8.77 | | .61 |
| 578671 | 20–50 | 15.80 | | 2.94 |
| Cajon sandy loam: | | | | |
| 578672 | 0–12 | 9.45 | | .47 |
| 578673 | 12–72 | 10.74 | ++ | 1.33 |
| Chino fine sandy loam: | | | | |
| 578674 | 0–12 | 17.87 | | 1.38 |
| 578675 | 12–29 | 17.27 | + | 1.41 |
| 578676 | 29–48 | 27.53 | | 2.81 |
| 578677 | 48–72 | 30.30 | | 15.07 |
| Chino loam: | | | | |
| 578678 | 0–16 | 30.30 | | 1.37 |
| 578679 | 16–28 | 26.31 | | 1.30 |
| 578680 | 28–50 | 38.37 | | 3.10 |
| 578681 | 50–81 | 13.47 | + | .61 |
| Foster fine sandy loam: | | | | |
| 578682 | 0–24 | 16.51 | | 1.44 |
| 578683 | 24–72 | 13.15 | + | 2.70 |
| Hanford loamy fine sand: | | | | |
| 578684 | 0–18 | 10.66 | | .57 |
| 578685 | 18–72 | 10.49 | | 1.02 |
| Lewis fine sandy loam: | | | | |
| 578686 | 0–4 | 14.45 | | .96 |
| 578687 | 3–12 | 39.60 | | 1.20 |
| 578688 | 12–21 | 33.35 | + | 3.57 |
| 578689 | 21–40 | 15.90 | + | 3.64 |
| 578690 [4] | 40–52 | | + | 6.38 |
| 578691 | 52–60 | 20.72 | + | 11.47 |
| Tujunga sand: | | | | |
| 578692 | 0–14 | 5.03 | | .25 |
| 578693 | 14–72 | 1.98 | | .18 |
| Delano clay loam: | | | | |
| 578694 | 0–15 | 23.60 | | 1.18 |
| 578695 | 15–46 | 23.35 | | 3.29 |
| 578696 | 46–68 | 23.81 | | 6.14 |
| 578697 | 68–80 | 27.60 | | 1.35 |
| Exeter loam: | | | | |
| 578698 | 0–10 | 14.75 | | .59 |
| 578699 | 10–26 | 15.62 | | .60 |
| 5786100 [4] | 26–32 | | | .57 |
| 5786101 | 32–54 | | | 1.56 |
| 5786102 | 54–66 | 12.82 | | 1.38 |
| San Joaquin loam: | | | | |
| 5786103 | 0–16 | 14.42 | | .75 |
| 5786104 | 16–24 | 14.63 | | .79 |
| 5786105 [4] | 24–34 | | | .62 |
| 5786106 | 34–66 | 15.43 | | 1.22 |
| San Joaquin clay loam: | | | | |
| 5786107 | 0–14 | 14.97 | | .65 |
| 5786108 | 14–21 | 15.24 | | .73 |
| 5786109 | 21–30 | 16.54 | | .74 |
| 5786110 [4] | 30–34 | | | .59 |
| 5786111 | 34–54 | | | 1.01 |
| 5786112 | 54–62 | 16.02 | | 1.12 |
| Chualar sandy clay loam: | | | | |
| 5786113 | 0–10 | 15.45 | | .68 |
| 5786114 | 10–30 | 15.10 | | .85 |
| 5786115 | 30–48 | 14.32 | | .76 |
| Ducor clay loam: | | | | |
| 5786116 | 8–10 | 25.52 | | 1.57 |
| 5786117 | 10–20 | 22.29 | | 3.40 |
| 5786118 | 20–38 | 25.49 | | 7.03 |
| 5786119 | 38–47 | 23.95 | | 8.75 |
| 5786120 [6] | 47–55 | | + | 3.87 |
| Porterville adobe clay: | | | | |
| 5786121 | 0–12 | 34.70 | | 1.43 |
| 5786122 | 12–30 | 37.50 | | 3.85 |
| 5786123 | 30–60 | 38.90 | + | 13.26 |
| Honcut loam: | | | | |
| 5786124 | 0–12 | 14.22 | | .74 |
| 5786125 | 12–60 | 14.96 | | .75 |

See footnotes at end of table.

TABLE 12.—*Determinations of moisture equivalents and carbonates in soils of the Pixley area, Calif.*—Continued

| Soil type and sample No. | Depth | Moisture equivalent | Sodium carbonates [1] | Carbonates [2] |
|---|---|---|---|---|
| Lassen stony adobe clay: | *Inches* | *Percent* | | *Percent* |
| 5786126 | 0–15 | 23.35 | | 1.32 |
| 5786127 | 15–26 | 22.70 | | 2.28 |
| 5786128 [7] | 26+ | | | |
| Linne clay: | | | | |
| 5786134 | 0–10 | 33.58 | | 18.12 |
| 5786135 | 10–17 | 32.85 | | 20.02 |
| 5786136 | 17–44 | 32.90 | | 22.10 |
| 5786137 [8] | 44–60 | | | 62.45 |
| Ducor adobe clay: | | | | |
| 5786138 | 0–18 | 29.07 | | 2.94 |
| 5786139 | 18–24 | 31.45 | | 5.77 |
| 5786140 | 24–53 | 28.09 | | 11.33 |
| 5786141 | 53–62 | 15.92 | | 2.70 |
| Ducor clay: | | | | |
| 5786142 | 0–12 | 34.14 | | 4.70 |
| 5786143 | 12–22 | 33.47 | | 6.24 |
| 5786144 | 22–34 | 33.50 | | 8.37 |
| 5786145 | 34–46 | 31.74 | | 9.57 |
| 5786146 [9] | 46–60 | | | |
| Hovey adobe clay: | | | | |
| 5786147 | 0–14 | 31.30 | | 1.92 |
| 5786148 | 14–30 | 31.60 | | 2.58 |
| 5786149 | 30–50 | 29.89 | | 13.13 |
| 5786150 | 50–72 | 22.47 | | .97 |
| Redding gravelly loam: | | | | |
| 5786151 | 0–8 | 14.67 | | .29 |
| 5786152 | 8–15 | 13.68 | | .29 |
| 5786153 | 15–19 | 29.75 | | 2.11 |
| 5786154 [4] | 19–30 | | | 1.61 |
| Las Posas stony clay loam: | | | | |
| 5786155 | 0–14 | 19.20 | | 1.76 |
| 5786156 | 14–24 | 16.12 | | 1.37 |
| Vista sandy loam: | | | | |
| 5786157 | 0–10 | 12.49 | | 1.40 |
| 5786158 | 10–22 | 11.96 | | 1.38 |
| 5786159 | 22–26 | 12.45 | | 1.62 |
| Exeter sandy loam: | | | | |
| 5786163 | 0–13 | 10.99 | | 1.27 |
| 5786164 | 13–28 | 10.03 | | 1.39 |
| 5786165 [4]— | 28–38 | | | 1.44 |
| 5786166 [4]— | 38–48 | | | 1.69 |
| 5786167 | 48–66 | 8.59 | | 1.60 |
| Chualar clay loam: | | | | |
| 5786168 | 0–10 | 19.47 | | 2.09 |
| 5786169 | 10–34 | 18.65 | | 2.86 |
| 5786170 | 34–54 | 17.97 | | 3.50 |
| 5786171 | 54–62 | 19.21 | | 2.97 |
| Madera clay loam: | | | | |
| 5786172 | 0–7 | 22.14 | | 2.42 |
| 5786173 | 7–20 | 27.65 | | 2.52 |
| 5786174 | 20–34 | 30.95 | + | 3.63 |
| 5786175 [4] | 34–40 | | | 2.25 |
| 5786176 | 40–60 | 33.40 | | 2.04 |
| Diablo adobe clay: | | | | |
| 5786177 | 0–10 | 25.41 | | 2.34 |
| 5786178 | 10–23 | 26.35 | | 2.15 |
| 5786179 | 23–30 | 18.57 | | 1.56 |
| 5786180 | 30–39 | 23.45 | | 2.32 |
| 5786181 | 39–54 | 21.35 | | 1.54 |
| 5786182 [7] | | | | 1.76 |
| Greenfield sandy loam: | | | | |
| 5786183 | 0–12 | 11.29 | | 1.23 |
| 5786184 | 12–40 | 9.45 | | 1.32 |
| 5786185 | 40–55 | 8.97 | | 1.35 |
| 5786186 | 55–70 | 8.67 | | 1.35 |

[1] By phenolphthalein solution.
[2] By the McMiller method.
[3] Stratified.
[4] Hardpan.
[5] Variable-textured alluvium.
[6] Sandy material.
[7] Bedrock.
[8] Caliche.
[9] Granitic substratum.

### CARBONATES

The percentage of carbonates was determined by the McMiller method, in which the soil is treated with hydrochloric acid until effervesence ceases and then titrated back with sodium hydroxide to determine the amount of acid that is consumed in the reaction, calculating the amount as calcium carbonate. It is recognized that this method involves certain errors, inasmuch as all carbonates are destroyed, as well as some other readily soluble compounds. Some of the soils, particularly those of the heavier textures, contained appreciable amounts of sodium salts, mainly chlorides and sulfates, with small quantities of carbonates, and other soils contained very high quantities of calcium carbonate with some magnesium. The figures showing the distribution of carbonates brings out the very high content in the Tulare soils. The hardpan horizon of Madera loam has a high content of lime, and the material below the hardpan likewise has a large content. Linne clay has a calichelike horizon between depths of 44 and 60 inches, which contain more than 62 percent of carbonates. This is the highest lime content of any horizon studied in the area.

### REACTION

The chemical reaction of these soils was determined by the glass-electrode method. Nearly all of the soils show neutral to basic reaction except Redding gravelly loam, which gave a mildly acid reaction. The pH values are given in table 13.

TABLE 13.—*Determinations of pH values*[1] *of samples of typical soil profiles from the Pixley area, Calif.*

| Soil type and sample No. | Depth | pH | Soil type and sample No. | Depth | pH |
|---|---|---|---|---|---|
| Tulare very fine sandy loam: | *Inches* | | Lewis fine sandy loam—Continued | *Inches* | |
| 578604 | 0–24 | 8.0 | 578690 | 40–52 | 9.4 |
| 578605 | 24–34 | 9.0 | 578691 | 52–60 | 9.1 |
| 578606 | 34–64 | 9.2 | San Joaquin loam: | | |
| Fresno fine sandy loam: | | | 5786103 | 0–16 | 7.3 |
| 578644 | 0– 5 | 10.5 | 5786104 | 16–24 | 8.0 |
| 578645 | 5–15 | 10.3 | 5786105 | 24–34 | 8.4 |
| 578646 | 15–23 | 10.0 | 5786106 | 34–66 | 8.3 |
| 578647 | 23–33 | 10.2 | Ducor adobe clay: | | |
| 578648 | 33–60 | 9.4 | 5786138 | 0–18 | 8.1 |
| Hesperia sandy loam: | | | 5786139 | 18–24 | 8.3 |
| 578649 | 0–12 | 7.6 | 5786140 | 24–53 | 8.5 |
| 578650 | 12–42 | 8.5 | 5786141 | 53–62 | 8.7 |
| 578651 | 42–72 | 9.0 | Redding gravelly loam: | | |
| Hanford sandy loam: | | | 5786151 | 0– 8 | 6.6 |
| 578661 | 0–16 | 7.9 | 5786152 | 8–15 | 6.6 |
| 578662 | 16–72 | 7.8 | 5786153 | 15–19 | 6.2 |
| Chino fine sandy loam: | | | 5786154 | 19–30 | 6.9 |
| 578674 | 0–12 | 8.5 | Vista sandy loam: | | |
| 578675 | 12–29 | 9.6 | 5786157 | 0–10 | 6.6 |
| 578676 | 29–48 | 9.0 | 5786158 | 10–22 | 7.2 |
| 578677 | 48–72 | 8.2 | 5786159 | 22–26 | 7.8 |
| Lewis fine sandy loam: | | | Greenfield sandy loam: | | |
| 578686 | 0– 4 | 7.7 | 5786183 | 0–12 | 7.2 |
| 578687 | 3–12 | 8.8 | 5786184 | 12–40 | 7.5 |
| 578688 | 12–21 | 8.9 | 5786185 | 40–55 | 7.5 |
| 578689 | 21–40 | 9.1 | 5786186 | 55–70 | 7.8 |

[1] Determinations made by the glass-electrode method, using a 1:2 suspension.

## SUMMARY

The Pixley area is in the southwestern part of Tulare County, Calif. It comprises 897 square miles, or 574,080 acres. Nearly all of the area is in the San Joaquin Valley; the rest occupies a narrow margin of the Sierra Nevada foothills. The valley land lies at an elevation ranging from 200 to 300 feet above sea level, and the foothills range in elevation from 400 to 1,000 feet.

Lines of the Southern Pacific system and of the Atchison, Topeka & Santa Fe Railway serve the area. Good paved highways and roads reach all sections.

The climate is semiarid. The summers are warm and dry, and the winters are moist and mild. The mean annual temperature at Porterville is 63.9° F., and the mean annual rainfall is 10.11 inches. As the rainfall is low, most of the crops are irrigated. The upper valley slopes adjacent to the foothills are known as the thermal belt because of good air drainage and relative freedom from winter frosts. It is in this so-called thermal belt that citrus fruits are grown.

The first settlement in this section was made about 1850, and Tulare County was organized in 1852. The population increased rapidly after the development of irrigation. Porterville is the only large town within the area. Pixley, Alpaugh, Tipton, Terra Bella, Ducor, Richgrove, Woodville, and Springville are smaller towns. Visalia, the county seat of Tulare County, is situated about 30 miles northwest of Porterville, outside the boundaries of this area.

Many different crops are grown, including citrus fruits, olives, and figs along the foothills; grain on the unirrigated plains south of Porterville; and alfalfa, cotton, table grapes, raisin grapes, peaches, prunes, walnuts, truck crops, and several other crops on the irrigated soils in the central part of the area. Dairy products, cattle, poultry, and eggs also are important sources of income.

The soils of the Pixley area have been classified in 29 series, embracing 56 types and 11 phases, in addition to 3 miscellaneous land types.

The Vista, Las Posas, Lassen, Diablo, and Linne soils occur in the foothill district and are developed in place on consolidated bedrock parent materials. Most of these soils are shallow or stony and steep and are used mainly for pasture.

Soils with permeable subsoils that occupy the recent to young smooth gently sloping alluvial fans and flood plains include members of the Hanford, Tujunga, Honcut, Foster, Cajon, Greenfield, Hesperia, and Chino series. The Hanford and Honcut soils are brown, and the Tujunga and Cajon soils are light gray or light brownish gray; both represent recently deposited materials. The Greenfield and Hesperia soils are brown and have a youthful profile; they differ in lime content. The Foster and Chino soils are dark brownish-gray and have higher lime and organic-matter contents than the other soils. All these soils are used, under irrigation, for a wide range of fruit, vine, and field crops.

Soils with moderately to strongly developed profiles and compact to dense subsoils include members of the Porterville, Delano, Chualar, Ducor, Pond, Waukena, Tulare, Hacienda, and Hovey

series. The Porterville soils have a heavy adobe texture and are chocolate brown. They are developed on basic igneous outwash material and have highly calcareous subsoils. As they occur in the thermal belts, they are used for growing citrus fruits. Distinguishing characteristics of the Hovey soils are their dark-gray clay surface soils of adobe structure and heavy-textured subsoils high in lime. The Ducor soils occupy the elevated terraces southeast of Terra Bella. They are dark grayish brown, have subsoils that are fairly compact and carry a high content of lime, and have substrata composed of softly consolidated granitic material. These heavy-textured soils are used chiefly for dry-farmed grain. Most of the brown or dark-brown Delano and the Chualar soils lack a supply of water for irrigation and are used mainly for dry-farmed grain and pasture. The Pond and Tulare soils are developed in flat areas of poorly developed drainage, the latter on old lake-laid sediments of former Tulare Lake. With these are associated small and unimportant areas of the Waukena and Hacienda soils, which have very dense columnar solonetzlike subsoils. All these soils contain saline and alkali salts and are used mainly for pasture.

The soils having cemented hardpan substrata include brown to red soils with brown silica-and-sequioxide-cemented hardpans and light-colored soils with lime-cemented hardpans. The brown and pronounced reddish brown soils are mainly noncalcareous and occupy sloping older alluvial fans, valley plains, and terraces, characterized, for the most part, by hog wallows. They include soils of the Exeter, San Joaquin, Redding, and Madera series. The Exeter soils have brown surface soils resting on an iron-and-silica-cemented hardpan at a depth ranging from 2 to 5 feet. Under irrigation these soils are used for the production of citrus fruits, grapes, and olives. The San Joaquin soils are reddish brown and have red clay subsoils resting on an iron-and-silica-cemented hardpan. They are costly to level and prepare for crops. Citrus fruits are grown to some extent where the hardpan is broken up by blasting. The Redding soils are a pronounced reddish brown and have highly colloidal clay subsoils resting on cobbly hardpans at a depth ranging from 15 to 30 inches. These soils occupy elevated terraces along the Tule River. Their agricultural value is low. The Madera soils have brown or light-brown surface soils and brown heavier textured calcareous subsoils. Below the subsoil is a silica-and-iron-cemented hardpan that contains considerable lime. Some of the lower lying areas of the Madera soils contain alkali.

The light-colored soils with calcareous hardpans have been developed in low flat valley plain and valley basin areas under conditions of poorly developed drainage and accumulated saline and alkali salts. In physiographic position, relief, and environmental conditions they are related to and associated with the Pond, Traver, and Waukena soils. They include the Lewis and Fresno soils. They occur in the western third of the area. They have gray or light-gray surface soils. The Fresno soils have light-gray lime-cemented silty hardpan layers at a depth ranging from 2 to 4 feet. The Lewis soils have heavy-textured subsoils of columnar solonetzlike structure resting on a calcareous hardpan. These soils contain

alkali in sufficient quantities to render them useless for the growth of crops.

The nonagricultural miscellaneous land types are rough stony land, rough stony land (Vista soil material), and riverwash.

The Pixley area receives its gravity water supply for irrigation mainly from the Tule River, Deer Creek, and the White River. A large part of the water used in irrigation is obtained by pumping from underground sources. With the exception of dry-farmed grains, all crops are irrigated.

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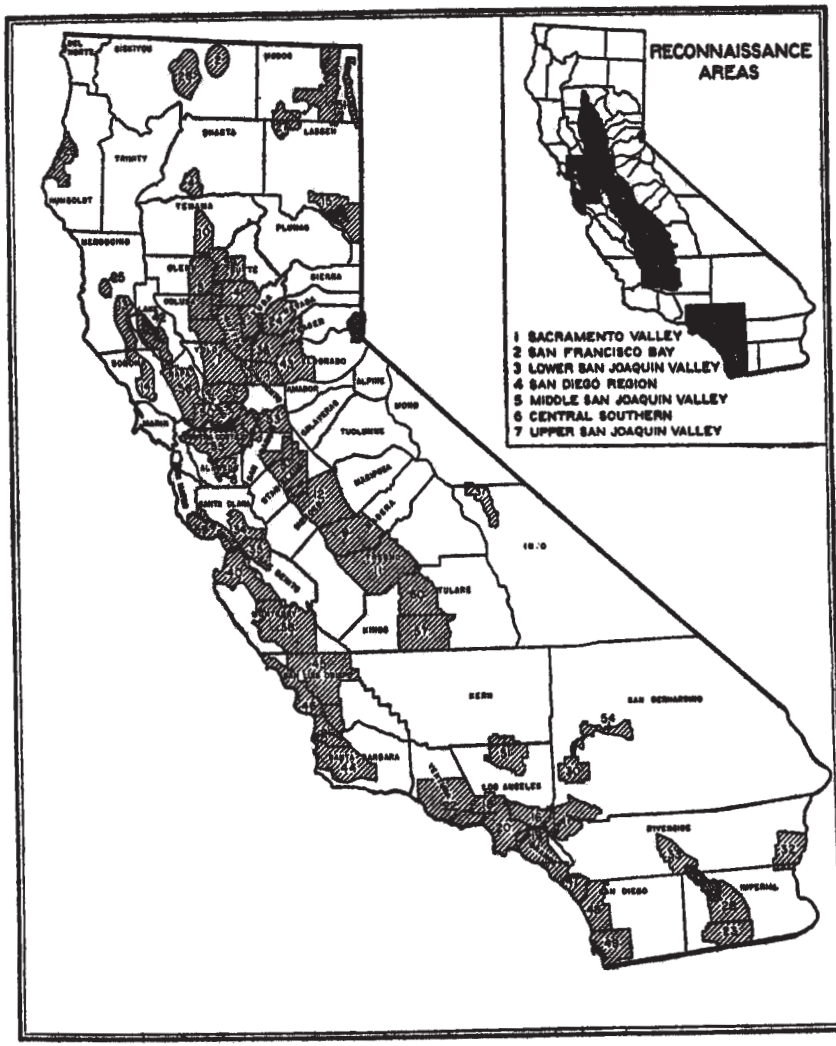


Areas surveyed in California, shown by shading

1. Sacramento
2. Butte Valley
3. Colusa
4. Redding
5. Modesto-Turlock
6. Marysville
7. Woodland
8. Livermore
9. Madera
10. Red Bluff
11. Fresno
12. Merced
13. Ukiah
14. Healdsburg
15. Honey Lake
16. Pasadena
17. Riverside
18. San Fernando
19. Anaheim
20. Los Angeles
21. Santa Maria
22. Ventura
23. El Centro
24. Grass Valley
25. Willits
26. Shasta Valley
27. Big Valley
28. Brawley
29. Eureka
30. Victorville
31. Lancaster
32. Palo Verde
33. Coachella Valley
34. Gilroy
35. Hollister
36. Auburn
37. Bishop
38. King City
39. Chico
40. Salinas
41. Oroville
42. Clear Lake
43. Placerville
44. Santa Ynez
45. Paso Robles
46. San Luis Obispo
47. Capistrano
48. Oceanside
49. El Cajon
50. Suisun
51. Alturas
52. Dixon
53. Lodi
54. Barstow
55. Contra Costa
56. Napa
57. Pixley
58. Sacramento-San Joaquin Delta
59. Santa Cruz
60. Visalia

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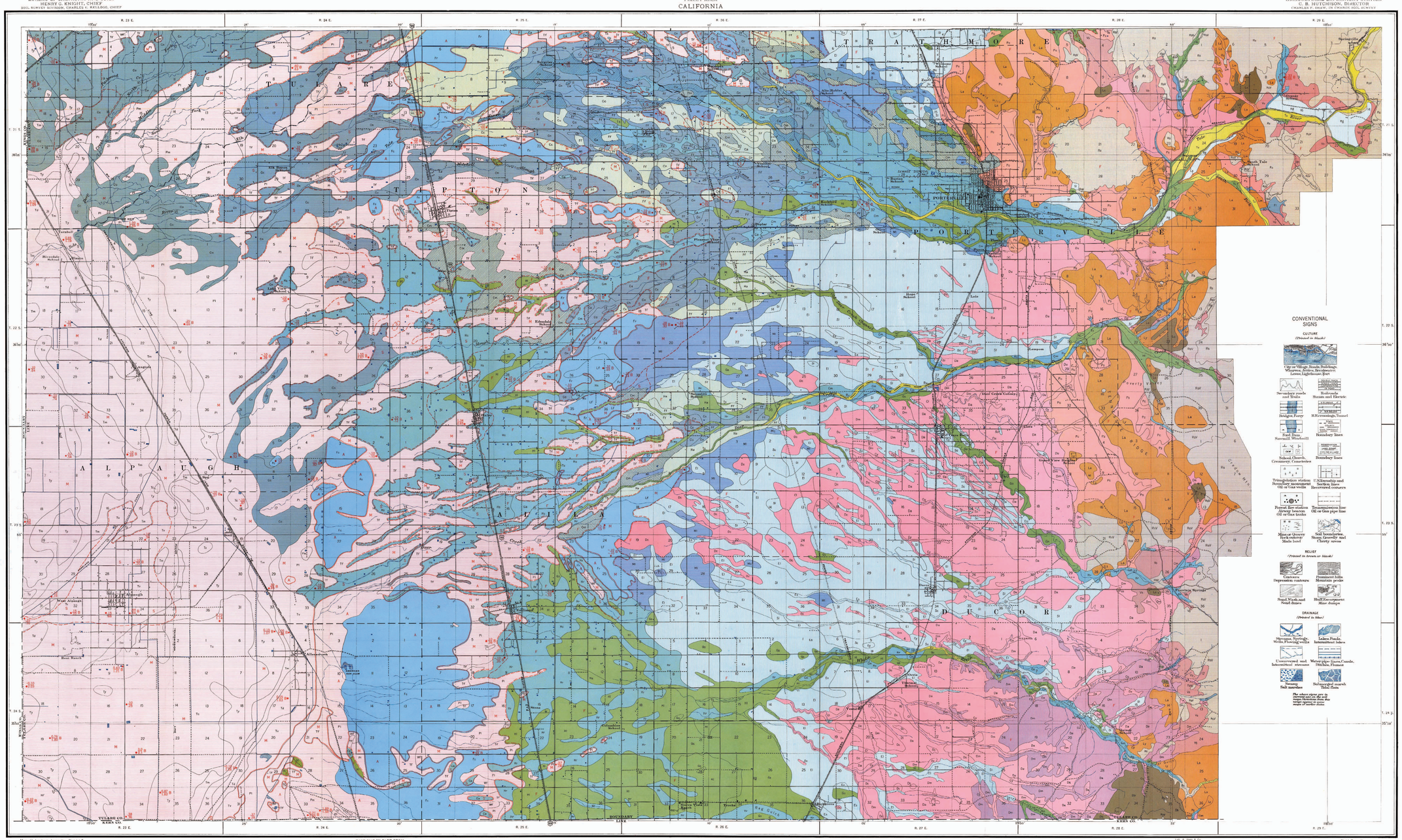
# SOIL MAP
PIXLEY AREA
CALIFORNIA

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
C. B. HUTCHISON, DIRECTOR
CHARLES F. SHAW, IN CHARGE SOIL SURVEY

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CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Levees, Breakwaters, Levees, Lighthouse, Fort
Newcastle
Newcastle roads and Trails
Railroads
Stores and Electric
Bridges, Ferry
Railroad, Tunnel
Ford, Dam, Narrowgauge, Woodenroll
Boundary, State
School, Church, Cemetery, Cemeteries
Boundary lines
Triangulation station, Boundary monument Oil or Gas wells
U. S. Township and Section lines Meandered corners
Forest Fire station, Ranger houses, Oil or Gas leases
Transmission line Oil or Gas pipe line
Mine or Quarry, Rock outcrop, Made land
Soil boundaries, Stony, Gravelly and Clayey areas

RELIEF
(Printed in brown or black)

Crevasses, Depressions, crateroes
Prominent hills, Mountain peaks
Sand Wash and Sand dunes
Bluff Escarpments, Minor changes

DRAINAGE
(Printed in blue)

Streams, Springs, Wells, Flowing wells
Lakes, Ponds, Intermittent lakes
Unsurveyed, and Intermittent streams
Water pipe lines, Canals, Ditches, Flumes
Swamp, Salt marshes
Submerged marsh, Tidal flats

*The above signs are in general not on the map, but are shown to explain certain features on some maps of earlier date.*

## LEGEND

### DEEP PERMEABLE SOILS ON GENTLY SLOPING ALLUVIAL FANS AND FLOOD PLAINS

LIGHT-COLORED NONCALCAREOUS SOILS (Grayish and tan)

- Greenfield sandy loam — Gs
- Hanford loamy fine sand — Hs
- Hanford sandy loam — Hl
- Honcut loam — Hm
- Tujunga sand — Tu
- Tujunga sandy loam — Tl
- Chino sandy loam — Ch
- Chino fine sandy loam — Cs
- Chino loam — Cn
- Chino clay loam — Cc
- Foster loamy sand — Fs
- Foster fine sandy loam — Ff
- Foster loam — Fl

DARK-COLORED CALCAREOUS SOILS (Brown to reddish)

- Cajon sandy loam — Ca
- Shallow phase — Cp (Over Chino soil material)
- Cajon fine sandy loam — Cm
- Hesperia sandy loam — Hs
- Hesperia loam — Hr
- Cajon sandy loam, Shallow phase — Cg (Over Madera soil material)
- Cajon fine sandy loam, Shallow phase — Cm (Over Madera soil material)
- Cajon fine sandy loam, Shallow phase — Cp (Over Pond soil material)
- Chino loam, Shallow phase — Cn (Over Madera soil material)
- Chino clay loam, Shallow phase — Cc (Over Fresno soil material)

SALINE AND ALKALI SOILS

- Tujunga stony sand — Ts
- Riverwash — Rv
- Foster fine sandy loam, Shallow phase — Ff (Over Madera soil material)
- Hanford loamy fine sand, Shallow phase — Hs (Over Madera soil material)

### SOILS OVER BEDROCK, IN FOOTHILLS

SHALLOW SOILS OVER BEDROCK

- Vista sandy loam — Vs
- Diablo adobe clay — Db
- Lance clay — Ld
- Lassen stony adobe clay — La
- Lassen clay — Ly
- Las Posas stony clay loam — Ls
- Las Posas clay loam — Lm
- Rough stony land — Rs
- Rough stony land, Vista soil material — RsV

### SOILS WITH DENSE OR MODERATELY DENSE SUBSOILS, ON ALLUVIAL FANS AND VALLEY PLAINS

MAINLY DARK-COLORED SOILS (Brown to reddish)

REDDISH AND EXCESSIVELY DRAINED

- Honey adobe clay — Hy
- Porterville stony adobe clay — Ps
- Porterville adobe clay — Pk
- Ducor clay loam, Rolling phase — Dm
- Ducor adobe clay, Rolling phase — Da

PEDREGAL GRAVELLY AND STONY

- Hacienda fine sandy loam — Hf
- Pond loam — Pl
- Pond clay loam — Pm
- Traver fine sandy loam — Tf

MAINLY GRAYISH AND YELLOWISH SOILS

- Chualar sandy clay loam — Cy
- Chualar clay loam — Cl
- Chualar clay — Ck
- Delano clay loam — Dc
- Ducor clay loam — Dm
- Ducor clay — Dk
- Ducor adobe phase — Da

PEDREGAL GRAVELLY AND SALTY

- Tulare fine sand — Td
- Tulare very fine sandy loam — Tv
- Tulare loam — Tm
- Tulare clay loam — Ty
- Tulare clay — Tc
- Waukena fine sandy loam — Wf

### SOILS OVER HARDPAN, ON OLD ALLUVIAL FANS AND VALLEY PLAINS

CALCAREOUS, CHIEFLY RED UPPER SOILS

- Chualar sandy clay loam, Shallow phase — Cy (Over San Joaquin soil material)
- Madera loam — Ml
- Exeter sandy loam — Es
- Madera clay loam — Mc
- Exeter loam — El
- Exeter clay loam — Ec
- Fresno fine sandy loam — Fr
- Redding gravelly loam — Rg
- Fresno clay loam — Fs
- San Joaquin loam — Sl
- Lewis fine sandy loam — Lf
- San Joaquin clay loam — Sc

NONCALCAREOUS, DARK GRAY TO BROWN, FRIABLE SUBSOILS

STRONGLY ACIDIC, GRAVELLY AND STONY

VERY ROUGH AND STEEP

PLANOSOLIC GRAY AND BROWN FRIABLE SOILS OVER HARDPAN

### SALTS AND ALKALI

- Strongly affected — A
- Moderately affected — M
- Slightly affected — S
- Free — F

*NOTE.—Locations of borings and results of field tests shown thus: 5/2 S*

*The upper figure shows the percentage concentration in the surface foot*

*The lower figure shows the average concentration in depth sampled.*

*The letter "S" indicates presence of black alkali.*

Lith. A. Hoen & Co.

Mary H. Lapham, Inspector, District 5.
Soils surveyed by R. Earl Storie, in charge, and Bruce C. Owen, University of California, and M. H. Layton, A. C. Anderson, W. J. Leighty and C. C. Nikiforoff, U. S. Department of Agriculture.

BASE MAP IN PART FROM U. S. GEOLOGICAL SURVEY SHEETS

Scale 1 inch=1 mile
1/4 0 1/2 1 2 3 4 Miles

Field Operations
Bureau of Chemistry and Soils
1935